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A NOTE ON RECENT VOLCANIC ACTIVITY ON THE ETHIOPIAN PLATEAU, AS WITNESSED BY A RISE OF THE LEVEL OF LAKE WONCHI 1400 ± 140 B..P

BY

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CONTENTS:

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1. INTRODUCTION

In June 1957 the present author visited the Lake Wonchi area some 150 kilometers West of the Ethiopian capital. Afterwards, in January 1962, I made a renewed visit to the lake and its immediate surroundings to the West, and in February of the same year I made a flight over the highland with the aim of getting bird-view sights and camera shots of the lake basin, but without much success, as the flight was hindered by highly turbulent and unstable air. One of the first observations I made at the beautiful highland lake, situated at about 2 900 m (9 500 feet) above sea level, was the existence of large tree stubs in the water of the lake on its northern shore and around the island outside the shore. The stubs, judging from the texture and the red colour of the wood, seemed to be remnants of an old *Juniperus (J. procera HOCHST.)* forest originally fringing the lake like the Juniperus forest still fringing the crater lake on the summit of Mt Zuquala S of Addis Ababa at the same altitude. My first impression was that the stubs were due to a rise of the lake level during the Last Pluvial (Gamblian Pl.) or the Nakuran wet phase of the Postpluvial of East Africa, the latter broadly coinciding with the Boreal of the N European Post Glacial (cf. Nilsson 1949, p. 207 and 1955, p. 46). At that time, moreover, I was uncertain whether the lake had (or did not have) an outlet; seemingly, and also according to the British 1 : 500 000 map it lacked one. This was confirmed by oral information from the German geographers Josef Werdecker and Wolfgang Kuls, who somewhat earlier, the former in 1954 and the latter in 1955, had visited Lake Wonchi.[1] The Swedish geologist Erik Nilsson had made several observations on dead trees at lake shores in East Africa

[1] Neither of them, however, mentions this observation in their subsequent publications; Werdecker 1955, p. 309 has a short note on the »jungvulkanische

and Abyssinia, and interpreted the phenomenon as appears from the following quotation from one of his papers (Nilsson 1940, p. 34): »It is evident that these trees grew during a climate dryer than that which now prevails in East Africa. They were drowned by the rising lakes during a following wet phase — —». His picture of »Tree stubs and trunks standing on their roots in Lake Naivasha» (op.cit., p. 35) could indeed as far as the stubs are concerned be from Lake Wonchi. The dead trees at Lake Shala in the Ethiopian Rift Valley, mentioned by Nilsson, remaine on a wider belt extending up to 8 m above the present lake level, and descend only 1 m below it. Consequently he interpreted the trees as a sign of a recent decrease in the lake volume.

However, there are facts which do not fit into the picture of a water-body fluctuating with the climatic epochs. Firts of all is to be mentioned the outlet of the lake to the S, at least a temporary one, confirmed by information from G. G. Last, Headmaster of the Medhane Alam School in Addis Ababa, who has travelled quite extensively in the Lake Wonchi area. It is also clearly indicated in two recent papers, the Awraja Description (Fitaorari Tsahai 1960, p. 51 »outlet from Southeast, joins the Walga river, no other outlet»), and in Haberland 1960 (map, p. 11). Furthermore, reading Julius Büdels Klima-Morphologische Arbeiten in Äthiopien im Früjahr 1953, directed my thoughts away from searching the solution in eustatic changes of the water-body. Büdel strongly opposes Nilsson's views on the development of the Ethiopian Rift Valley Lakes, either completely denying their greater extension in former times or explaining these fluctuations as caused by endogenic events and not by exogenic-climatic ones (Büdel 1955, p. 150). It seemed more appropriate to reconsider the riddle of the dead tree stubs against the background of possible changes of the shape of the lake basin itself. A. final decision against the climatic-eustatic theory was reached as samples of the tree stubs in Lake Wonchi which I had sent to Finland in 1957 were in early 1963 time-determined to $1\,400 \pm 140$ B. P. (A. D. 550) at the C^{14}-Laboratory of the Geological Survey of Finland [1] (Radiocarbon 5, 1963, p. 303).

Bergland um den prächtigen Kratersee Wontschi» with the additional information that the crater brim lies at 3 400 m above sea level, but Kuls does not at all notify his trip to L. Wonchi in Kuls 1956.

[1] It is my pleasant duty to express my deeply felt gratitude to the Head of the C^{14}-Laboratory, Dr. Esa Hyyppä, for the free use of its services.

Thus the only possible solution to the enigma of the drowned trees in Lake Wonchi seems to lie in a consideration of events of an endogenic nature, *viz.* 1. A diminishing of the lake basin by an upheaval of the lake bottom or parts of it, 2. A diminishing of the lake basin by filling up with volcanic materials, 3. A subsidence of the lake shore or parts of it, and 4. A heightening of the treshold where L. Wonchi has its outlet, either by upwarping or by lava-outpouring. One of these events, or some, or all of them acting together could have created conditions which rather suddenly brought about the drowning of the Juniperus trees growing on the shore of the lake. A more definite and precise answer as to how it happened cannot at the moment be given. I have, however, thought it worth while to present some points of view on the matter. For this purpose I have thoroughly studied some air photos of Lake Wonchi which I have obtained through Mr. G. G. Last and Mr. Gunnar Schalin (at one time teacher at Haile Selassie I Secondary School in Addis Ababa), to both of whom I want in this connection duly express my sincere gratitude. On the basis of the air photos and with the help of an Old Delft Scanning Stereoscope a large scale map of Lake Wonchi has been constructed and reproduced in the present paper (Fig. 10).

2. THE REGION

The Lake Wonchi area forms a part of a broadly E — W stretching highland region along the Southern border of the northern greater part of the Ethiopian Highland, called the Amhara Highland by Julius Büdel (Büdel 1955, p. 142). From this latter the highland region is dissected by large open valleys and plains at an height of 2 000 to 2 300 m., whereas the highland itself lies at 3 000—3 300 meters with crests up to 3 400—3 500 m. It is a water divide area drained by tributaries to the Hawash river in the East, by the river Guder and tributaries to Guder, in the North and West, and by tributaries to the Ghibie river in the South. The Ghibie River Valley lies some 70 kilometers away in the SW and the Blue Nile Valley about 100 kilometers to the N. Both are situated at a level of about 1 000 meters and the incision and erosional activity of the watercourses flowing in these directions has therefore been much stronger than the corresponding one of the headwaters of the Hawash river to the East, where the valley of the Hawash lies much higher at an

elevation of about 2 000 meters (but also closer, about 50 kilometers from the E end of the highland). The width of the hinghland is in the East about 20 kilometers. In the West, where the headwaters of the Guder and Ghibie come very close it narrows to only a few kilometers. The W end culminates in Mt Jibati at 3 072 meters, according to the 1 : 500 000 map and is almost isolated from the rest of the highland by the erosion of the above mentioned waters.

The dissection of the Lake Wonchi Highland from the Amhara Highland is probably mainly due to the work of normal fluviatile erosion. However, it seems very likely that internal forces are partly responsible. The fault block nature of the Kaffa Highland, which has been pointed out by Schottenloher (Schottenloher 1938, p. 205), seems to continue here in the border zone between the Amhara and the Kaffa Highlands. The locally very steep and very straight delimitation of the Amhara Highland along the line Addis Ababa—Ambo—Ghedo, as well as the string of thermal springs along it (cf. map. Tav. III in Dainelli IV, 1943) seems to indicate a fault line. As a matter of fact Schottenloher on his map sketch has drawn a southwards-facing faultscarp here, marking what he calls the »Südrand der Unzerstückten Abessinischen Scholle», running due E — S from a point 80 km E of Addis Ababa to a point immediately N of Ambo (Schottenloher 1938, p. 208).

The high frequency of irregularities in the drainage pattern (the juxtaposition of dendritic, rectangular and trellis patterns is a quite common phenomenon in the area S of the Addis Ababa — Ambo — Ghedo line, and barbed river junctions also appear on the map) indicate that internal forces have played an important role in the origin of the relief, through the movement of fault-blocks or the extrusion of lava flows.

The relief features of the L. Wonchi Highland are characterized on the whole by large, even plateau-surfaces with clearly incised valleys in the border zone of the highland at a height of about 2 900 to 3 000 meters, both in the N and the S. The landrover road from Ambo to L. Wonchi (which continues to Woliso, cf. fig. 10) gives a fair cross-section of the N part of the hinghland. The road starts at the awraja office (Ager Gizat) at 2 160 m above sea level. For six kilometers it runs SE on an even or gently undulating plateau until it crosses the narrow valley of the river Taltalli at 2 360 m. For seven kilometers more the road follows the same SE course with the river

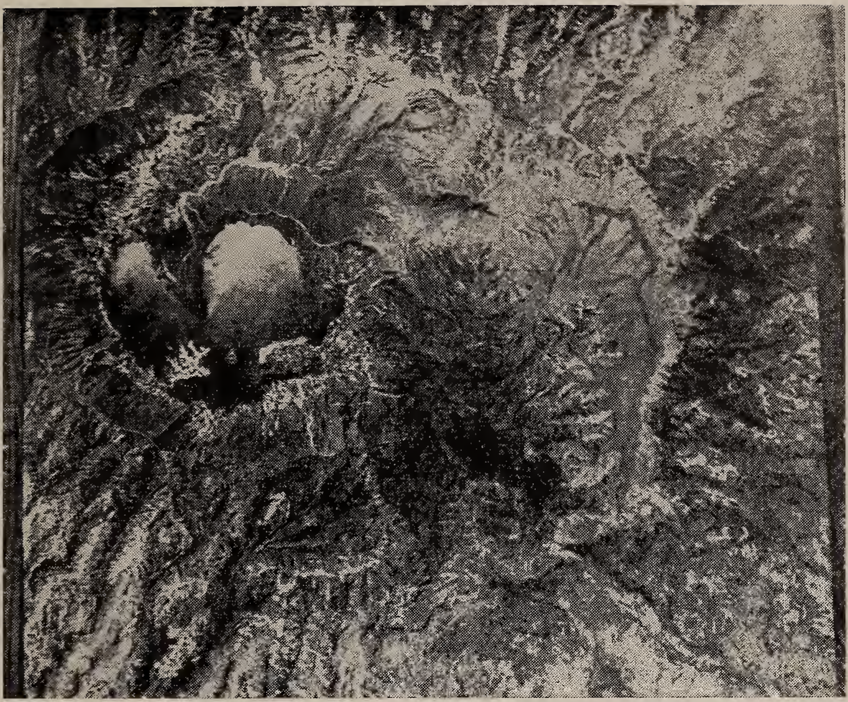

Fig. 1. A vertical air-photo of the Lake Wonchi area with the Haro plain to the right (West).

flowing in a slowly deepening valley N of the road. At a point 2 710 m. above sea level the road turns due S running straightly over an open slowly rising plateau surface. At 17 kms from Ambo at a height of 2 950 meters the first bamboo grove is met with and also scattered Juniperus trees. A valley to the W of the road ends up here in a perfect circular valley-head with small cultivated terraces at a height of 3 000 m. This may be taken as the beginning of the L. Wonchi Highland Proper (cf. fig. 2). The slope is steeper, about 70 to 80 meters a kilometer (against 30 to 40 meters during the first kms of the total road distance to L. Wonchi, which is 25 kms), and the plateau surface is cut by quite deep valleys. An old cult place surrounded by a wooden fence called Ja I Chabbo Cherkos after the Chabo tribe (cf. Cohen 1931, p. 60; Haberland 1960, pp. 10—12) and situated at a level of 3 070 m. lies already within the predominantly uncultivated part of the highland. The steeper slope with deep valleys continues to about 21 kms distance from Ambo (and 4 kilometers from

the crater brim. At a height of 3 210 meters the last cultivated fields are left behind. From here onwards the plateau surface is again even or only gently undulating until within about two kilometers ahead of the quite steep outer crater brim.

Around Lake Wonchi the plateau relief is broken by ridges and hills. All over the hihgland it is easy to get extensive views of the landscape, both above the natural forest line and below it. The scrub of the *Ericaceous* Belt or heath zone (cf. Hedberg 1951, p. 164 and Scott 1952, p. 92) is low and scarce through extensive grazing and burning; in some valley-heads of the outer crater brim there are dense thickets of *Arundinaria alpina* K. SCHUM. or of *Rapanea simensis* (HOCHST.ex DC.) MEZ. As a rule a canopy is very seldom formed in the *Hagenia-Hypericum* zone, low solitary standing trees of the secondary growth being the rule, for example *Nuxia congesta* R.BR. ex FRES., the rounded crowns of which stand out conspicuously at the time of blooming as white bouquets in the grey-brown carpet of the lower vegetation. In the *Juniperus* zone a real forest is even more seldom encountered, as fields and grassy pasturages here are common. Some huge trees may be seen, often clearly left standing for religious cult ceremonies but a canopy is extremely rare in the Eastern and Central parts of the highland I have seen, and also in the Western ones according to the Awraja [1] Description (Fitaorari Tsahai 1960, pp. 45—46).

The *Kleinformen* of the plateau surface are interesting. Firstly, sharp edges of the ridges are in places quite common, in fact they are so sharp, that there is only room for a narrow path. This form, very common on the brim itself, seems to have its origin in the structure of the rock (loose tuff). Secondly, open, broad-bottomed valleys with steep slopes are common, especially above 3 200 meters; these valleys most often lack surface drainage, even if there may appear occasionally a spring or at least a small swamp on the valley bottom. The subsurface flow is here a strong morphological agency, especially during the rainy season, but also during the dry winter season, being at that time aided by the *Wechselfrost* climate of Carl Troll (Troll 1943), the alternation of freezing and thawing temperatures during the span of a 24-hours day-and-night cycle. The landforms thus created by soil

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[1] An awraja is the first sub-division of the Ethiopian province, the awraja Ager Hiwot (Ambo) is thus a sub-division of the Shoa province. It occupies a large part of the drainage basin of the Guder river, except the L. Wonchi Highland in the S of the awraja.

Fig. 2. A view northwards from a hill, at 3370 m, E of my camp from 25th to 28th January 1962. The dissected edge of the L. Wonchi highland is clearly discernable, especially the Juniperus-clad spur with the Ja I Chabbo Cherkos in the center. In the background the front of the Amhara Highland can be seen as an obscure black line. Photo H. Smeds, 26th January 1962.

creep, Büdels *Flächengleiten,* in the upper highland zone, the dega zone of the Ethiopian plateau from about 2 500 meters upwards, have to a considerable extent their origin in a former, more humid climate, probably during the Last Pluvial of East Africa. At that time solifluction was, according to Büdel, active on slopes of only 3° gradient, whereas nowadays, solifluction on a forested slope is to be observed only if the gradient exceeds 30° (Büdel 1955, p. 139, pp. 144—145, p. 155). Whatever their origin may be, these valleys, flat-bottomed, often sinuous and sometimes branching, are a common feature of the upper parts of the L. Wonchi Highland, and they are of a certain interest for the interpretation of the origin of the shore relief of the lake.

The trap sheets of the Ethiopian Plateau are thickest in its eastern parts adjoining the Rift Valley, where they measure up to 2 000 meters (Krenkel 1926, p. 6, p. 56, p. 98, Sanders 1929, pp. 17—18), thinning out towards the W and the N. As the underlying sedimentary rocks are

exposed at elevations as a rule falling below 1 500 meters in valleys N, W, and S of the Lake Wonchi Highland, with the exception of parts of the upper Guder Valley (Dainelli 1943 II, pp. 383—409), it seems that the lava cover of the block must be of considerable thickness. After Blandford (Blandford 1870), one is used to discern three different trap series in Ethiopia, two older, the Ashangi and Magdala series, covering the Plateau itself, and one younger, the Aden series, covering the Rift Valley parts of the Abessomalian Block. The extrusion has taken place in connection with the uplift of the block and its different parts. Werenskiold has quite recently explained the frequent occurrence of volcanic phenomena along the uplifted flank of a fault as due to a rupture in the balance between temperature and pressure caused by uplift (and/or down-faulting). »In a strip below the uplifted flank the pressure will be lowered, and in some cases so much that the solid matter will pass into a liquid state; the magma is forced upwards, issuing at the surface as lava flows» (Werenskiold 1953). It seems very tempting to think that this is the mechanism by which the volcanic activity has repeatedly originated along the whole uplifted side of the Ethiopian Plateau abordering the Rift Valley, including the L. Wonchi Fault-block. — Quite recently the age sequence of the tectonic events in Northern Ethiopia has been treated by Dr. Y. Abul-Haggag. He is of the opinion that the discharge of the lavas was intermittent, and that the early ejection of the traps must have taken place only after the uplifting had started (as proved by the inclination of the foundation on which they have been spread; cf. Abul-Haggag 1961, pp. 27—36 and especially pp. 30—32 Age and Origin of the Traps).

3. THE LAKE AND ITS ORIGIN

Apart from the three trap series mentioned above younger parts of the lava plateau are discerned; by Dainelli on his map III of the distribution of volcanic phenomena in former Italian East-Africa (Dainelli 1943 III) they are designated as »principale masse laviche recenti sugli altipiani». And in addition there are very recent signs of volcanic activity, which, however, are restricted to the Afar lowland, to the area of the Aden series, as is generally agreed. Dainelli, it is true, quotes in passing a note by Antoine d'Abbadie that ash rains were observed in different parts of the Ethiopian plateau in 1804 and 1836,

but he assumes that these ejections emanated from volcanoes situated in the lowland (Dainelli 1943 III, p. 667). On Dainelli's big map in 1 : 2 000 000 is a small area (approx.10x6 miles) E of Ambo marked as »formazioni eruttive delle zolle affossate (pliocene superiore—attuale)» but there is no comment on this occurrence in the text or even mention of it. The much larger Mt Egan area W of the Ghibie river, designed with the same colour on the map, is referred to in the text shortly with the remark »dovrebbero rappresentare una fase eruttiva molto piu recente di quella degli espandimenti stratioidi (Dainelli 1943, IV Tavoli and III, 1943, p. 142). The Lake Wonchi Highland is marked by the colour designating »trappi degli altipiani (oligocene — miocene)».

Büdel has on morphological evidence attempted to divide the younger series in three subdivisions. *The first* is largely characterized by the complete eradication of primary volcanic concavities through long lasting erosion. It is thought to be of Late Pliocene to Early Pleistocene age. As examples the old volcano remnants around Addis Ababa are mentioned: Jerer, Furi, Mannagasha, and »Udschalli» (probably Wuchacha). *The second* is easily discernable from the first by still clearly recognisable primary volcanic land-forms, including crater lakes. As examples are mentioned Mt Zuquala with its well preserved crater lake, the young volcanoes of the Dankali Desert and the Rift Valley, the »gewaltigen Explosion-Calderas» and the subsequent secondary »Kegelaufschüttungen» of the latter, and lastly the lava barrage of Lake Tana. It is assumed to be of Middle to Young Pleistocene age. The second or »mitteljungvulkanische serie» has lasted long and Büdel thinks that the great majority of the Ethiopian lake basins have been created in connection with volcanic events during this period.[1] *The third* is characterized by still unweathered lava and is thought to be only the end phase of the former series.[2] As examples are mentioned Tandaho in the Middle Danakil,

[1] »Offensichtlich handelt es sich hier um eine sehr lange ausdauernde, in verschiedene Phasen gegliederte Eruptionsperiode: in den zugehörigen Tuffen fand ich zwischen Zuai- und Abiata-See fünf übereinander liegende fossile Bodenhorizonte. Der grösste Teil der äthiopische Seen ist in dieser Periode entstaden. Sie zeigen sämtlich erst geringe Verlandungsspuren (Büdel 1955, p. 152).

[2] »die bis in Gegenwart hineinragende rezent-subrezente Endphase der vorgenannten Serie, welche die sicher bereits im Holozän erfolgten Ausbrüche umfasst» (Büdel *in equo loco).*

Fantale with Lake Metahara, the still active volcanoes of Northern Danakil, and lastly 'a small crater' N of Zuquala.

L. Wonchi and the land forms accompanying the lake belong evidently to Büdels Second or Middle Young Volcanic Series, and the events causing the rise of the lake level in 1 400 ± 140 B.P. to its »rezent-subrezente Endphase», i.e. Büdels Third Young Volcanic Series.

Lake Wonchi is not often mentioned by scholars treating the Earth History and the Land Forms of Ethiopia. Krenkel has a short note on the volcanoes Dendy (3 000 m) and Harro, which arise SW of Addis Alem, W of the »Erer-Sukwala-Linie» (Krenkel 1926, p. 111). Dainelli also makes a short reference to the volcanoes Dendi and Horra and points out that they according to Borelli have craters and crater lakes (Dainelli 1943 III, p. 638). It is evident that Horra-Harro is the L. Wonchi mountain: the plain situated some 200 meters above and immediately W of the crater lake (cf. fig. 4) carries the name Haro, which in gallinja simply means the plain.

Jules Borelli was the first foreigner who visited Lake Wonchi or at least the first to describe it. He crossed the Wonchi highland from the East in 1887, from 14th to 18th November, passing by Dendi and halting for two nights at Lake Wonchi, or Wenchit in his rendering (Borelli 1890, pp. 266—270). Both are described as crater lakes, and Lake Wenchit is said to have a depth of 50 — 60 feet, a clear understatement. It seems evident, however, that these figures are based on sounding by a hand-line in some part of the lake as he says that the natives think that the bottom of the lake is red-hot and that a rope touching the bottom therefore will catch fire (sic!).

Of newer authors, there is as already mentioned — the German geographer Josef Werdecker. Büdel does not include the L. Wonchi crater in his study, the obvious reason being that he has not visited the lake. Neither has Paul Mohr in his short treatment of the Geology of Ethiopia (Mohr 1961) any mention of the lake, but on his map is marked, in addition to the thermal spring at Ambo W of Addis Ababa, another some 30 kms. southwards, which must be the one of Lake Wonchi. A former British Ambassador to Ethiopia, Sir Douglas Busk, has a report on his visit to L. Wonchi in The Fountain of the Sun (Busk 1957, pp. 36—37), which in a short statement: »It is an extinct volcano and the vast crater is filled with a glorious lake» and in the text to the accompanying colour-photo view of the lake gives as much information as Werdecker. The latter, however, has the

qualifying attribute »jungvulkanische» added to the highland around L. Wonchi, which seems to indicate that he includes the highland of L. Wonchi or at least a large part of it in Büdels 'young volcanic series'.

Lake Wonchi has larger dimensions than other Ethiopian crater lakes if depth as well as width is considered. As to the size of the whole crater basin, it is large indeed even compared to most concavities of similar origin throughout the world. The width of the basin from brim to brim is 4.8 $\times$ 4.0 kms, measured E — W and N — S, the width of the lake being 2.2 $\times$ 1.7 kms, measured in the same directions. The vertical dimension from the highest crest of the crater brim to the water level of the lake is about 500 meters. As for the depth of the lake, there are no records except that already mentioned, by Borelli, of 50 — 60 feet. The lake is certainly much deeper. During my first visit in 1957 I employed a 15-meters measuring tape as a lead-line in trying to find out the depth of the lake when crossing its northern end from the shore to Island Giorghis with the church. The result was that I lost contact with the bottom already some 20 meters from the shore. In other words the slope of the bottom is about the same as that of the steep interior crater wall i.e. about 40°. Even if it may seem audacious to judge from such small evidence (especially as there is reason to believe that the configuration of the bottom is as irregular as the horisontal shape of the lake with its large Southern promontory almost dividing the lake in two halves, and with its two smaller peninsulas and the island in an E — W row almost closing the uppermost Northern part) — I think it is quite a fair guess to assume a maximum depth of about 400 meters. If this be true the whole vertical dimension of the crater basin is 900 meters. This is not far from that of the famous Crater Lake of Oregon, 1 100 meters (cf. map in Louis 1960, p. 269; depth 600 meters, crater wall above water level about 500 meters). The latter has, however, far larger horizontal dimensions, 8.5 $\times$ 6.5 kms as for the lake, and 10 $\times$ 10 kms for the entire crater.

The crater brim is on the whole surprisingly even, varying as a rule only about 100 meters, as can be seen from the map, fig. 10. As for its absolute height, the mean of several aneroid readings, made by the author on 26th January 1962 for the point where the road down to the Achahaser settlement (on the N shore of the lake) crosses the brim, is 3 382 meters, which is coincident with Werdecker's, 3 400 meters and Busk's, about 11 000 feet (the latter's 1 500 foot descent to water level is also coincident with the 450 meters I recorded when descen-

ding on January, 26th, after noon; 3 400 m passpoint of the road at 12.25 o'clock, 2 950 m water level at 13.04 o'clock). The evenness of the brim may be judged from some aneroid readings the author made on January, 27th, during walks eastward and westward from the above mentioned passpoint: eastwards from the point, which at 8.45 a.m. read 3 362 meters (name of locality in brackets): 8.48 — altitude 3 315 m (Gommesa), 8.55 — altitude 3 330 m (Kibbi, highest point on NE side), 9.30 altitude 3 280 m (Atame, about 3.5 kms from the road passpoint) —; westwards about 600 meters from the point — altitude 3 450 m (Chala, meaning in gallinja, according to the Galla — English Dictionary I used during this trip, »bigger, larger, superior», as it is, indeed, the highest crest of the L. Wonchi brim),[1] 10 minutes farther SW altitude 3 425 m, 20 minutes a new crest of the same altitude (Ontu), 30 minutes altitude 3 395 m (Aro), 40 minutes 3 370 m (the road due W on the slope from

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[1] At Chala there are two copper plates with inscriptions, one reading Crater 1960 and the other (somewhat lower) Crater RM 1960. They have been put down by the American Geodetic Survey to Ethiopia levelling by triangulation from the Red Sea to Khartoum from 1960—. The altitude determined is probably the 3386.8 meters mentioned in the awraja description (Fitaorari Tsahai 1960, p. 67; cf. map fig. 10). It is lower by 63 meters than my single aneroid reading of 3450 meters on the 27th of January 1962. This coincides with the information I gathered in Addis Ababa at this time that the American determination of the altitude of the Ethiopian capital had given for the Railway Station a value 50 meters lower than the old French one, dating from the Djibouti railway levelling in 1917 (information by Herman Ruud, General Manager of Imperial Ethiopian Telecommunications). A single aneroid reading should, of course, not be given full evidence. The main point is that there is a 500 meters difference in altitude between Chala and the water level of the lake. The old Italian map of 1935 of Africa Orientale in 1 : 2.5 million (V Edizione, Istituto Geografico Da Agostini, Novara) gives 3 298 meters and the British 1 : 500 000 map of 1947 about the same value (10 827 feet). The International 1 : 1 million map does not have an altitude marked for Mt. L. Wonchi, but its altitudes for Mt Badda Rogghie, Mt Boti (N brim of L. Dendi) and Mt Jibati are respectively 3 550 m, 3 260 and 3 072 meters (the Awraja Description has no values for Bada Rogghie and Jibati, but for Mt Boti 3 268 m and for L. Dendi 3 150 m, i.e. the descent in altitude from the crest of Mt Boti to the water level of the lake is 118 meters). Lake Dendi, as I saw it from the air on the 12th of May 1962 and as appears from a photo in Haberland 1960 and from another one in the Awraja Description, is a perfectly regular double *maar* (Haberland 1960, p. 15 and Fitaorari Tsahai 1960, p. 60). It may be noted in passing that the plantations of *Ensete ventricosum* on the slope of Mt Boti, which are mentioned by Haberland in the text to the photo, are very likely the highest situated in the whole of Ethiopia.

Fig. 3. View from the same hill as in Fig. 2, westwards. The big hill in the background belongs to the dissected brim encircling the Haro plain: its altitude is probably about 3300 to 3350 meters above sea level. Down in the valley to the left are seen the first stands of the bamboo thicket which covers the valley-head, and above them some high kosso trees (*Hagenia abyssinica* (BRUCE)GMELIN). Photo H. Smeds, 26th January, 1962.

where we continued our trip downwards to Haro showed an altitude of 3 348 m which may give an impression of the steepness of the outer slope at this spot). — Opposite Chala on the SE side, the crater brim is also high, not much lower than the former; the highest crest (Kirrea-boi) marked by two solitary trees is clearly seen from everywhere on the crater brim. In the SW there is a notch in the crater brim, 1.5 kms wide and about 300 meters deep, through which the Lago Haro river (draining the Haro plain W of L. Wonchi) flows in a broad valley, into which it has cut a deep canyon-like gorge (cf. fig. 4, 7 and map, fig. 10). The Haro plain lies at an elevation of 3.150 to 3.170 m according to my aneroid readings on January, 27, 1962 (lowest point though, at the beginning of the gorge, at 3.120 m, cf. fig. 10). It is very level, and has a N — S dimension of 3.5 km and an E — W one of 1.8. km (cf index map upper right corner, fig. 10). The surrounding

brim is much more dissected and also lower than that of the L. Wonchi Crater Proper. In the North the brim is broken up in isolated hills. Some of these hills are among the highest in the whole area (cf. fig. 3).

Pecularities of the L. Wonchi basin worth stressing (except those already mentioned) are. *1.* The huge chasm, about 400 m deep, in the southern crater brim, through which flows the Walga river (cf. map, fig. 10), *2.* The asymmetrical shape of the southern promontory which has a very steep concave W side and a much gentler convex E side (the same asymmetry is also observed in the ridge bordering the large SW bay, except that the E slope is steep and the W one gentle), *3.* The strangely triangular steep-sloped hill rising about 250 meters at the base of the southern promontory, *4.* The hidden outlet from the lake just N of the triangular hill, where the brook, which later on, by joining the Lago Haro river, forms the Walga river, makes its beginning inside a ridge about 10 m high seemingly if not actually barring the outlet of the water from the lake, *5.* The great contrast between the lake shores, steep and even in the E and SW, low and intricately indented (cf. map fig. 10 and fig. 5) in the N and SE, and *6.* The »badland»-topography of the SE crater wall. Most of these features can be discerned on fig. 4, 5, 6, 7.

(Settlement is restricted to the lowest slope of the interior crater wall; the first hut encountered when descending from the N lies at 3 020 m, i.e. about 70 m above the lake level. It is a quite old and dense settlement. Two churches are found, one on the small Cherkos Island, one on the Dirre Peninsula. A third one is said to have existed on the Giorghis Peninsula (or Island as it is called) in the E, but according to tradition it was burnt down by Mohammed Granje during the Islam Invasion of the Ethiopian Highland at the Sixteenth Century. — The people seem to have a mixed origin. The substratum is the old Kuschitic stock common in almost all highlands of Southern Ethiopia. Then there has been an influx of Christian Amhara at Middle Ages, and another of Galla invaders from the Sixteenth Century, and from olden times until recently an infiltration of Guraghe people from the Guraghe Highland east of the Ghibie-Omo river. It is obvious that the inhabitants of the L. Wonchi Highland are possessors of another civilization than the surrounding Galla tribes. The cultivation of *Ensete ventricosum* (WELW.) CHEESMAN is their main support. Haberland has pointed out that the ensete cultivation is a »Leitfossil für das Überdauern der Vorbevölkerung» in certain highland areas of Central

Fig. 4. An oblique air-photo view of L. Wonchi from the NE. In the foreground the outer crater brim with incised dry valley-heads radiating from it. The white patches on the ridges are barley fields. In the far background to the right are seen the level Haro plain and the gorge cut in it by the Lago Haro river running behind the circular lower wall delimiting the lake in the SW. Above the crater brim to the right there is a glimpse of the Giorghis peninsula, the small Cherkos Island is seen in its entirety and of the Dirre pninsula its greater part. To the left the big Southern promontory and left of it the high triangular hill. Between them, the outlet valley and the ridge barring the outlet (»The Fasil Bridge»). The crest of the ridge is cultivated and therefore stands out clearly. The huge canyon in the outer crater brim through which the Walga river flows can be seen indistinctly, to the left and right (West) of it are light patches indicating a sparse settlement at high level on the upper part of the crater wall. Photo H. Smeds, February 11, 1962.

Ethiopia (Haberland 1963, p. 15, p. 528, cf. also Haberland 1960, p. 14). Today the lake-side settlement is heavily overpopulated, and as a consequence there has taken place a large expansion of the extensive barley-cultivation with burning on the slopes of the upper crater brim (as well as a seasonal emigration to other areas of the highland, and a final one to Addis Ababa). The expansion was obviously expressed in the views offered to the author at his second trip to L. Wonchi in 1962 as compared to those during his first visit in 1957. Especially in

the N and in the NW there are today barley fields on sites which must promote soil erosion).

The ancientness of the L. Wonchi settlement makes it highly probable that man has witnessed the last events of volcanism in the area, including the one which caused the drowning of the trees on the N side of the lake. According to a tradition which was told to the present author by his local guide during the 1962 visit (a man by the name Soboka, who was said to act as a priest at the church), the water came up as the people were dancing and celebrating a big festival. Or to quote him literally:» the land sank and the water (= the lake) was born». The same conception is expressed in the Awraja Description (Fitaorari Tsahai 1960, p. 51) with however a dating of the event when the lake came into existence »not long ago», as evidenced as it is said »by the many dry trees standing here and there in the water of the lake». Haberland relates a tradition from his L. Wonchi trip in 1955, according to which the crater basin from the beginning was dry, the two churches standing on small hills, but at the time of the persecution of Christian Amhara by Mohammed Granje the basin was flooded by the intervention of Emperor Fasil who to that end dammed the water of a brook and thus saved the Christian churches.[1] The belief of of the lake-dwellers, mentioned by Borelli (cf. above p. 14) that the bottom of the lake is red-hot glowing, as well as the worshipping of the thermal spring on the S side of the lake, may also indicate that the people of the L. Wonchi area have been eye-witnesses to volcanic events. It is even tempting to imagine that the first missionaries arriving at L. Wonchi (during the expansion of the Christian belief in Ethiopia at the High Middle Ages cf. Doresse 1957 II, p. 29, pp. 83—160) included the still living memory of the great catastrophe as as strong argument in their propaganda for the inefficieny of the protection offered by former gods.

The lake basins of Ethiopia have generally been classified as crater basins (cf. Krenkel 1926, p. 110, Dainelli III 1943, p. 637, Mohr 1961,

[1] »Nach einer Tradition, die ich am See hörte, war das Innere des ehemaligen Kraters ursprünglich trocken, die beiden, dem Heiligen Georg und dem Heiligen Cyriacus geweihten Kirchen standen auf kleinen Hügeln. Zur Zeit von »Mohammed Grañ» habe Kaiser Fasil (Fasiladas regierte in Wahrheit hundert Jahre später) das Wasser eines Baches stauen lassen und dadurch den See geschaffen, der die Kirchen vor den Mohammedanern rettete (Haberland 1960, p. 14).

p. 193, Last 1961, p. 196).[1] Many of them are simple explosion craters with only little or none, ejected materials and without or with only slightly raised crater brims. As examples of perfectly ideal *maar*'s of that kind seen by the present author may be mentioned the Arra Seitan lake [2] in SE Guraghe not far from Silte (cf. the short mentioning by Krenkel 1926, p. 111 and by Dainelli III 1943, p. 638 and a good reproduction in Mohr 1961, p. 185) and the Lake Bieber of Eastern Kaffa. Some of the Bishoftu Lakes associated with the Adda volcanoes (cf. Reck 1930) are also true *maar*'s (excellent reproduction in Life's Pictorial Atlas of the World, New York 1961, pp. 396—397). Lake Dendi in the Eastern corner of the L. Wonchi Highland is also a real *maar* with a perfectly circular shore line, even a double-maar like the Schalkenmehrener Maar in Eifel (cf. map in Louis 1960, p. 264) if not a triple-maar (cf. photo in Fitaorari Tsahai 1960, p. 40). The L. Wonchi basin on the contrary is a highly complex edifice, the origin of which can not be understood without assuming several stages in its development.

Dainelli has stressed the fact that the volcanoes of Ethiopia, as a rule, are small, and if there are bigger ones they seldom appear together. The small and very small ones, on the contrary, are very closely associated, as a matter of fact so closely, that they appear with cones and craters as parts of the same mountain, »un unico elemento orografico». It is, says Dainelli, as the manifestation of eruptive activity in Ethiopia could not concentrate for a long time in the same point, but instead tend to disperse itself over a large space, so that often each one of them (the volcanic manifestations) correspond to a special volcanic landform. And even in those cases

[1] Some of them are, however, lava-barred depressions, like Lake Tsana, or even calderas like Awasa-Shala and Shamo (Ruspoli) according to Büdel (Dainelli III 1943, p. 462 and Tav. III in the same volume, Büdel 1955, pp. 150—151). Dainelli's opinion of the Rift Valley lakes is best expressed by his own words: »sieno die sbarramento vulcanico o intervulcanici, ma non craterici» (*op. cit.* p. 639).

[2] Arra Seitan lies farthest South in a row of craters and small volcanoes stretching from Buttagira to Silte on the flank of the Ethiopian Rift Valley. It may be worth mentioning that the present author during a trip by mule from Silte to Koshe in August 1957 encountered some 7 km from Silti, NW of the Tufa Swamps, a terrain with fresh, unweathered lava, with rough blocks and stones and with singularly rough surface features: pits, basins and ridges alternating without order, a kind of Guraghe replica to the fresh lava fields in the Fantale-Metahara area, many times described in the geological literature (cf. Dainelli III 1943, p. 633), and visited by the present author in May 1958.

when it shows either a longer duration or a more concentrated local intensity, a displacement of the volcanic ablity can be verified quite often as demonstrated by the plurality and complexity of the craters in one and the same volcanic mountain.[1]

The L. Wonchi highland does not fit into the Ethiopian pattern. At Dendi, in the E corner of the highland region, volcanic activity seems to have manifested itself only once, giving solely one volcanic landform: the Dendi explosion crater or *maar* (even if it seems natural that just on this spot there has taken place an outflow of fluid lava from one or several volcanic vents at the first stage of the origin of the L. Wonchi highland). At L. Wonchi the volcanic activity must have repeated itself several times, so creating almost in the same point, following the classic pattern of volcanic activity, a more complex volcanic edifice.

L. Wonchi is not, as the interior of the Wuchacha and Jerer volcanoes in the vicinity of Addis Ababa, a crater basin much altered or deformed by fluviatile erosion. The huge canyon which opens a free passage for the outlet from the lake through the crater brim in the South, cannot have been created by river erosion, and L. Wonchi is thus not a kind of pre-stage to the horse-shoe volcano, which is a quite common volcanic land-form in Ethiopia. The origin of the chasm must be synchronous with the coming into existence of the crater basin itself, and a part of the same event. Most likely the huge chasm is a giant radial fissure, a rift opened by the explosion that gave birth to the crater basin. The predominance of cinder in the material which builds up the ring-wall around the crater basin, and the interior crater wall, as well as the circular form and the great depth of the basin indicate that an explosion with ejection of pyroclastic materials has been the main factor in creating the *grosso modo* shape of the L. Wonchi Mountain. The rift in the Southern crater brim through which the Walga river flows must have originated simultaneously or at least in close connection with the explosion, as a conse-

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[1] »Tutto cio induce a ritenere che le mainifestazioni eruttive non sieno state, generalmente concentrate per lungo tempo in uno stesso punto, ma invece disperse su largo spazio, in modo che spesso ad ognuna di esse corrisponda una speciale costruzione vulcanica; ed anche in quei casi nei quali esse mostrano una maggiore o durata o intensita locale, deve essersi comunque verificato, assai spesso, uno spostamento dell'asse eruttivo, dimostrato dalla pluralità, e talora molteplicità, dei crateri in uno stesso monte vulcanico» (Dainelli III 1943, p. 641).

Fig. 5. A view across the lake from the crater brim in the East. In the foreground, on the lake the sinuous deep inlets in the S part of the Giorghis peninsula can be clearly seen. Cherkos Island is partly obscured by an intruding *Erica arborea* bush growing right out horizontally from the steep interior crater wall. Continuing it the Dirre peninsula whose dorsale, assymetric and rising close to 50 m above the level of the lake can clearly be seen. In the far background the indistinct white line indicates the Haro plain. To the left in the foreground is seen the outermost tip of the S promontory. Photo H. Smeds, January 27, 1962.

quence of the great tension, or the subsequent disruption in pressure balance through the ejection of huge quantities of material.[1]

Of the major features which build up the L. Wonchi basin area the large Haro plain in the West is the most conspicuous. The brim encircling the Haro plain is, as already mentioned, more dissected and also in general lower than the brim of the crater. It seems therefore likely that this landform is older than the crater basin proper. Lacking

[1] The tuffitic rock exposed at the roadside where the path to Achahaser settlement crosses the Northern crater brim is extremely fine-textured. Erosion by human and animal feet has here cut down the path in this soft rock to a depth of at least 5 meters. The descent down the interior crater wall arises at the dry season clouds of dust. During the heigth of the rainy season it is reported to be almost impossible to climb the path because of the slipperly mudflow it is transformed to, and the lake-dwellers are thus for weeks cut off from the world.

Fig. 6. A view from the North slope of the crater brim across the Dirre peninsula and the inlet separating it from the North shore, also seen on the picture. In the far background the notch which marks the lowest part of the outer crater brim, where the large canyon of Walga river is incised (concealed by the inner crater brim). The indented shore line of both Dirre and Achahaser stands out. Photo H. Smeds, January 26, 1962.

petrological evidence it is difficult to ascertain the nature and origin of the Haro plain. It could be the subsidence caldera of an older volcano, the larger part of which has been destroyed or buried beneath the ejections of the L. Wonchi explosion, in many ways a replica to the Monte Somma — Vesuvius edifice (cf. Rittman 1962, pp. 127—131, Louis 1960, p. 267). As a matter of fact this possibility was suggested to the author by Mr. G. G. Last in 1962. An interesting feature in connection with the Haro plain is the deep gorge about 1 km long, cut by the Lago River in the Eastern end of the plain. The V-formed end of the gorge as well as the upper part of the gorge is clearly seen on fig. 4 and the whole canyon on fig. 7 (cf. also map, fig. 10). When was the difference in altitude between the Haro plain and the lower Lago Haro valley bottom created that started the retrograde erosion of the canyon, and how did it originate? By a subsidence of the terrain where the lower Lago Haro river now flows, or by an upwarping of the Haro plain? These are questions which cannot

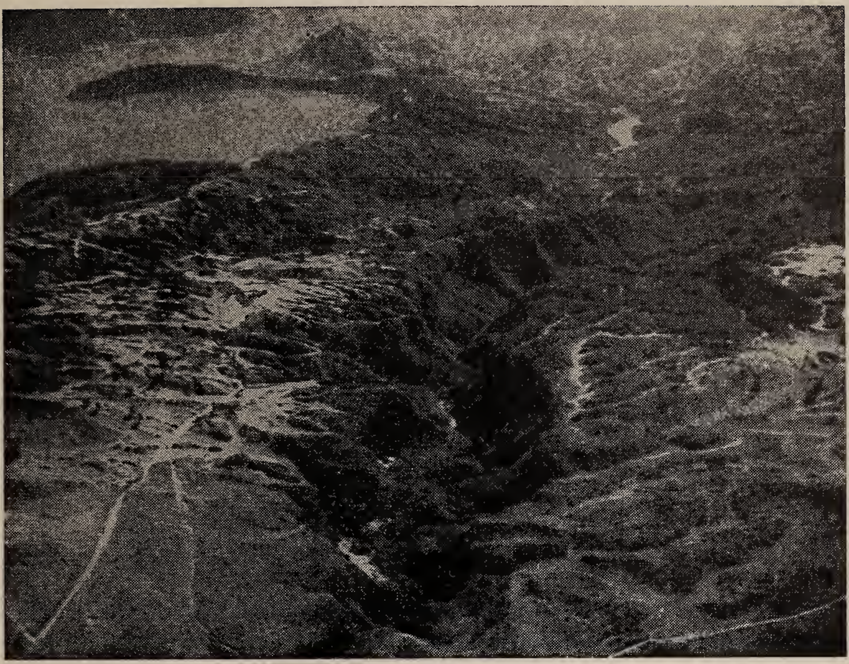

Fig. 7. An oblique air-photo view of the Lago Haro canyon, and in the left background the S end of L. Wonchi with its S. promontory and the triangular hill. In the foreground the E end of the Haro plain, and right a piece of the Ambo-Woliso road. The flat valley-bottom with the mineral springs can be seen as a white patch in the upper right corner. Photo H. Smeds, February 11, 1962.

be answered for the moment. On the question of the age of the land-movement in question and the start of the retrograde erosion of the gorge the author is tempted, however, to put forward some points of view. It does not seem probable that he sculpturing of the canyon started with a land-movement connected with the events which drowned the Juniperus trees at Lake Wonchi, because a regression of the gorge of 1 000 meters in 1 400 years, i.e. 0.7 m. a year, does not seem very convincing taking into consideration the small amount of waters streaming through the canyon. If the annual rainfall is 1.500 mm [1] and the discharge coefficient 0,6, the mean flow is only 0.5 cbm/sec. Even given great differences in the hardness of

[1] In nearby Ambo at 2 150 meters level the annual rainfall is 1.064 mm (Guide Book 1954, p. 135) in Addis Ababa at 2 500 m 1.270 mm (Fantoli 1943, p. 170).

[1] Emperor Fasilidas is famous all over Ethiopia, at least its Christian parts for all the miracles he has performed. He was the monarch who expelled the Portuguese from Ethiopia in 1632.

the rock it is unbelievable that the small Lago Haro river should have cut back its canyon at a rate about haft the annual amount of the Horseshoe waterfall in Niagara (with a mean flow of 5.900 cbm/sec.). On the other hand the freshness of the feature does not seem to indicate that the retrograde erosion started as early as the origin of the big explosion crater. In this connection it should be remembered that the water flow of Lago Haro has been much ampler in a geologically speaking quite recent time, the Last Pluvial of East Africa. It seems most probable that the difference in altitude was created and that the subsequent backward-erosion started in connection with the origin of the minor features of the L. Wonchi basin.

Most conspicoous of those are the sharp-edged ridge which encircles the SW bay of L. Wonchi, and the triangular hill due east of the outlet. The former is not likely a lava outflow from the interior crater wall, but most probably the brim of a smaller interior explosion crater within the bigger one. The above mentioned asymmetry with the crest close to the concave side of the brim points towards such an interpretation. When the explosion has taken place cannot be decided lacking evidence of every kind, neither can it be decided whether the explosion was only a gaseous one or connected with ejection also of pyroclastic materials. The triangular hill, a feature which morphologically exhibits the same freshness as the adjoining circular crest, may have been extruded as an endogenous lava dome (cf. Rittman 1962, p. 125) simultaneously with the explosion. The events are likely to have created landslides on the interior crater wall, and the present author is inclined to interprete the big crater scar, marked as »badland» topography on the map, fig. 10, as the result of such a landslide.

The events that caused the drowning of the trees $1\,400 \pm 140$ years B. P. remain to be explained. Of the four possibilities that might have caused a rise of the lake level, mentioned on p. 2, numbers 3 and 4 seem to be the most likely ones. The barring of the outlet is almost sure to have happened as witnessed by the ridge marked on map fig. 10. As to the subsidence of the shores or parts of them, the surest evidence would be a map showing the distribution of dead trees in the water of the lake. The present author has found such trees in the N shore waters and in the waters around Cherkos Island. They are lacking in the waters outside the end of the Dirre peninsula, and also in certain parts of the shore waters fringing the Achahaser settlement, but this may only prove that the forest

Fig. 8. Mineral spring and herd of cattle brought in for drinking the water from a region 80 km in the W. The spring as well as other, smaller ones, used for curative purposes by the L. Wonchi people, is situated on a flat valley bottom N of the river Lago Haro (cf. fig. 10). Photo H. Smeds, June, 14, 1957.

was cleared and the land taken into cultivation already 1400 ± 140 years B. P. The Awraja Description (p. 51) says that dry trees are found »here and there» in the lake. If a closer investigation should show that dead trees are found only outside the indented shores (cf. map, fig. 10, and fig. 1) this would be a point in favour of the partial subsidence hypothesis. It seems almost certain that the very intricate indentedness of the shore line, as shown for the Giorghis peninsula on fig. 5, could only have originated in the submersion of a terrain sculptured by fluviatile erosion, and maybe still more of one where the periglacial subsurface flow has been very active (cf. above p. 5).

The ridge that bars the outlet from the lake is called the Bridge of Fasil by the inhabitants. The water of the brook is flowing subterranously through the ridge, forming thus a kind of »natural bridge». It is a very narrow channel about 2 m deep in which the brook flows. When the author explored its W end in June 1962 it was almost dry. The question as to how the subterraneous river channel was formed is not easy to answer. It seems most likely

Fig. 9. Thermal spring on wall, encircling the valley bottom on fig. 8. As seen the spring gushes out about 3 meters above the knickpoint of the slope. Note worshipping the pole in the left foreground with clothes offered. The water is warm (not hot) about 35°—37°C differing thus markedly from the Ambo and the Filoha (in Addis Ababa) thermal springs. Photo H. Smeds, June 14, 1957.

that in the flow of pyroclastics and fluid lava, which formed a bar across the outlet from the lake, at the very beginning originated fissures and cracks into which the dammed up water seeped. The very tiny flow of water observed in the brook on June, 14, 1957, (when the first rains already had fallen) leads the author to think that there may exist hidden outlets for the lake water. The computed mean discharge from L. Wonchi is about the same as from the Haro plain, 0.5 cbm/sec. This must at the time of the year mentioned imply a flow in the brook of at least 1 cbm/sec., if not more, which surely did not take place. On the other hand, the thermal spring on the backside of the circular ridge enclosing the SW bay of the lake has an ample flow of water (cf. fig. 9). It seems only appropriate to suppose that a part of the water out-flow from Lake Wonchi runs through fissures in that ridge. The water in the spring would thus be wadose water heated to the comparatively low temperature of about 36 centigrades in the way from the lake to the out-pouring at the valley-bottom.

4. CONCLUSION.

It seems that the development of the Lake Wonchi Highland and the land-forms associated with the L. Wonchi Crater Basin has taken place in the following order:

1. An out-pooring of fluid basic lavas in association with continuing uplift, during Late-Mesozoic to Early Tertiary times created the foundation of what was later to become the L. Wonchi Highland *senso lato.* Its dissection as a distinct part of the greater Amhara Highland took place slowly subsequently as a result of long lasting river erosion and fracturing of the land-block through tension created by differing rates of uplift.

2. The L. Wonchi Highland Proper was created in a following stage of lava-outpooring coincident with Julius Büdels First Young-Volcanic series of Late Pliocene to Early Pleistocene Age. The lava extruded at this time was somewhat more acid and more viscous than the underlying foundation and the edge of the lava-sheet, lying today at about 3.000 meters, stands out as an easily recognisable topographical feature.

3. At a later time, coinciding with Büdel's Second Young-Volcanic series of Middle to Young Pleistocene Age, when for reasons not recognisables, movements in the pyromagma and changes in pressure gave rise to an accumalation of gases, big explosions took place, which created the most conspicuous features of the L. Wonchi Highland Proper, the two crater lakes Dendi and Wonchi. For the former the endogenic events ended and subsequent erosion has since largely eradicated the S part of the crater brim. For the latter the big explosion marks only the initial stage in a long sequence of events of endogenic origin.

4. The subsequent stages, coinciding with Büdels Second and Third Young Volcanic series, comprise 1. at least one further explosion as evidenced by the steep-sided SW basin of L. Wonchi (= the interior crater), 2. the extrusion of an endogenous lava dome in the SE part of the outer crater, 3. a subsidence of the part of the outer crater which lies between the two crater brims in the Sonth, or an upwarping of the land W of L. Wonchi, as witnessed by the down cutting of the deep canyon valley of the Lago Haro river, and 4. in its latest phase events which took place from 1400 ± 140 B. P. Those events which are time-determined to the drowning of large trees in the waters of the N shore of L. Wonchi are most likely two or three connected ones: firstly, a

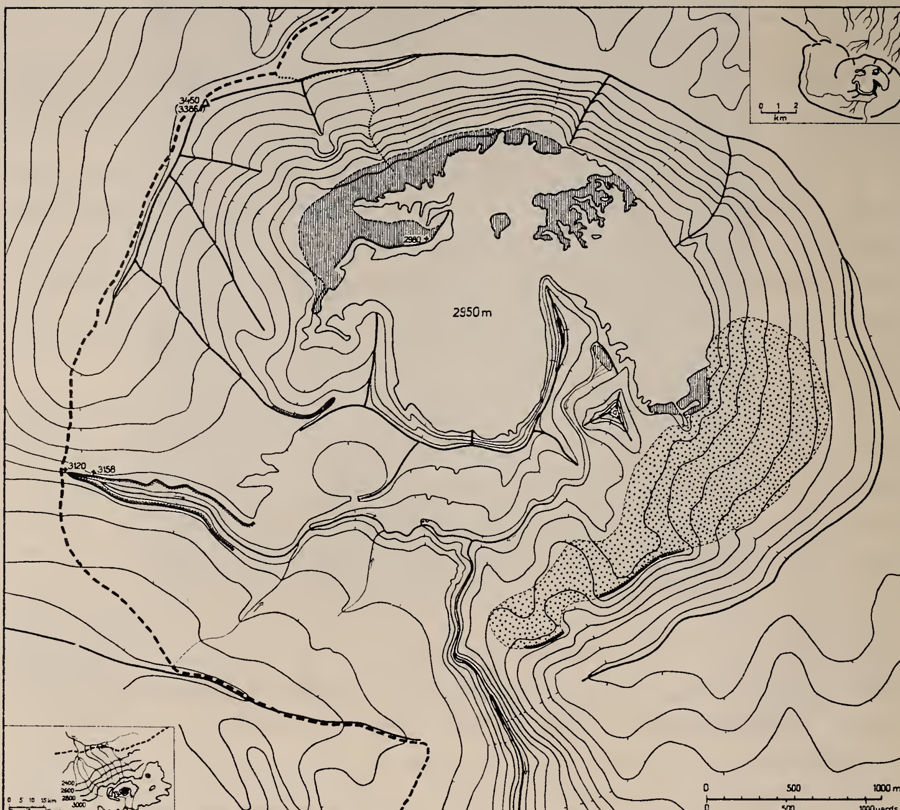

Fig. 10. Map of the L. Wonchi basin with the lake and the Haro plain, drawn on the basis of air-photos. The contour lines (even if spaced broadly at 50 meters vertical equidistances) are traced only to give an idea of the shape of the basin. Densely ruled areas indicate settled and cultivated ground. Scattered settlements on the SW interior crater wall are not marked on the map, however Stippled areas on the SE side of the crater basin indicate a »bad-land» terrain, strongly dissected by ridges and furrows. Crest-lines (»Kamm-Linien») shown by lines, scarps by 'sawtooth'-lines. Spot-heights as well as the level of the lake are according to the author's aneroid readings (in meters above sea level). The landrover route from Ambo to Woliso shown as a heavy dotted line, the path down the N crater wall to the Achahaser settlement as a thin dotted line. Inset, upper right corner and left lower corner, index maps, the former one with cam-lines and rivers drawn after the vertical air-photo of the area, the latter with contour lines and the Addis Ababa — Ambo road according to the British 1 to 500 000 map (L. Dendi as a black point to the ENE of L. Wonchi).

barring of the outlet by a lava-stream today standing out as ridge about 5 meters high through which the outlet brook flows in a narrow subterraneous channel; secondly, most probably a subsidence of parts

of the lake shores, easily recognised today as highly and intricately indented in strong contrast to the even shores of the rest of the lake; thirdly, it seems that the barring of the outlet might have had as a consequence the opening of a hidden outlet for the waters of L. Wonchi through the SW ridge (»the interior crater brim») to the thermal spring with its ample flow (cf. fig. 9) in the valley S of the ridge.

As a consequence of the present paper more attention than formerly must be paid to endogenic events, especially volcanic activity, in interpreting the present land-forms of the Ethiopian High Plateau. By using organic remnants found in other parts of the area for radiocarbon time-dating one could perhaps get a key to the events which must have found their expression over larger areas at about the same time. At the time of the writing the present author has received samples of tree-stubs from Lake Shalla collected in June 1964 by Herman Ruud, General Manager of the Imperial Ethiopian Telecommunications, most likely the same fossils mentioned already by Erik Nilsson. They are highly carbonized, and the structure and lightness of the wood suggests that they are remnants of *Aeschynomene Elaphroxylon* (Griell. & Perr.) Taubert. The time-determination which will follow in due course in the C^{14} — Laboratory of the Geological Survey of Finland is of great interest, as it will give one more of the evidences needed for what probably is recent earth-crust movements in Central Ethiopia.

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LONDON'S FIELD RESPONSE

IN TERMS OF POPULATION CHANGE

BY

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HELSINKI
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LONDON'S FIELD RESPONSE

in terms of population change

The writer of these lines has already examined in many connections the influence of central places on the distribution of the population. In his study published in 1953 he sought to find out some demographical phenomenon appropriate to being considered the response of people subjected to a statistically manageable stimulus. The averaged per capita assessed income of taxation statistics was found to be a suitable variate. It seemingly provoked characteristic reactions in the subjected people. There really appeared some interesting facts.

By expressing the stimulus intensities in terms of the logarithms of the income instead of its arithmetical values, the aggregate distribution could be resolved into four pure Gaussian distributions. The admixture of the sub-populations thus brought to mind, is shown in Fig. 1.

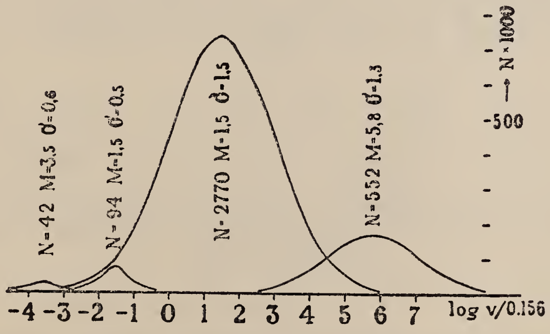

Fig. 1. Finland's population in 1934 as an aggregate of Gaussian collectives.

It must be emphasized that the four sub-groups of the population which are hereby introduced are, statistically speaking, definitely distinct collectives. Moreover, they represent realities as well. The biggest sub-group represents the main rural body of the population, and the

sub-group embodying the highest theoretical, *i.e.* regressed values represent the urban, or let us say, the non-rural population. Finally the small collectives on the extreme left of Fig. 1 are geographically and socially peripheral subgroups.

The net natural increase of population and the net rate of migration were then plotted against this background of distribution of the population; see Fig. 2. From this illustration one can directly conclude that natural and migratory changes in population numbers are, through the mediation of income intensity, dependent on the centrality of the place.

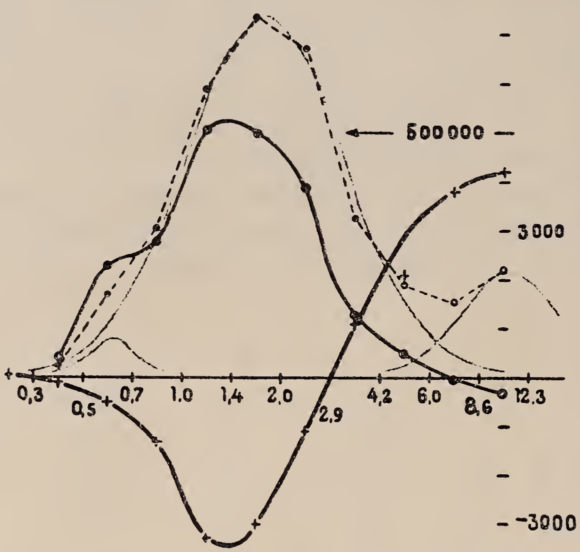

Fig. 2. Natural increase of population and the flow of net migration, shown against the background of the distribution of population. Net migration is shown by the sigmoidal curve.

Although the findings mentioned above covered the population of the entire country, it might have been expected that the central predominating dependence of the statistical variables considered, would also appear in a narrower framework, such as the sphere of influence of important towns.

To establish to what extent this supposition might be supported from observations made in 1954, the writer made a pilot study of

conditions in Finland based on the most recent statistics then available (for 1951). In the 40 cases with which it dealt the net rate of migration was shown to be dependent on the distance from the centre, as in the expression

$$y = c_0 + c_1 x + c_2 {\cos \atop \sin} (c_3\ x) \qquad (1)$$

where x indicates the positive square root of the distance from the centre and $c_{0,1,2,3}$ are constants (*v.* AJO 1954).

The writer has studied in more detail this dependence for Finland's second largest town, Tampere. In this connection, special attention has been paid to the variation of the aformentioned dependence in time. At the same time an explanation was sought to the circumstances connected with the alternative of the cosine or sine (AJO 1961 a & b).

Thereafter, the examination also concentrated on other demographic variates, *i.e.* birth and death rates, rates of in- and outmigration and the rate of total or gross change of population. The last-mentioned obey the same equation given above, only the parameters being different (see AJO 1962). This observation makes it possible to examine the validity of the equation presented above in conditions in which statistics concerning migration are not obtainable. As far as this is correct, it should be possible to begin to apply the equation for determining demographic fields and areas of influence. In this way a more certain basis for demographic estimates and forecasts could be arrived at.

In his earlier studies, the writer has observed that the variation is strongest in the vicinity of big cities where the actual statistical elements of the area are smallest and most numerous. Consequently, the fields of big cities give more points of observation, with more information for finding and describing the dependence here considered.

It was clear, however, that observations concerning the field of a big city could leave one doubting whether the dependence found therein was purely accidental, or peculiar only to the particular field of that city. More test subjects were therefore needed.

Assuming that similar stimuli give rise to similar effects, one may expect to find more evidence of a particular dependence when the test is replicated in possibly similar conditions. If the technique of replication is applied to different test subjects, *i.e.* fields under possibly similar conditions, the information obtained is still more valuable,

because the idiosyncracies of an individual test subject may then be revealed and prevented from vitiating the conclusions arrived at.

With this in mind, the writer made a parallel analysis of three capital cities in Northern Europe: Oslo, Stockholm, and Helsinki. They are equally suitable as test subjects because there are few, if any, big cities in the world with their environs so strikingly similar in most aspects of their life. Their otherwise manifold resemblance is geographically further emphasized by the fact that these cities lie on almost the same parallel of latitude, 60°N (AJO 1963). In all these three cases, the rate of total change of population was found to obey our equation in its sine form.

This is an important finding which must already be taken seriously. At the same time, it is a challenge to examine the extent to which the same dependence is suited to describe conditions in the field of a still larger centre, more densely populated and dominated by stronger forces.

THE PRESENT PROBLEM

It was particularly tempting to direct this study to London. That giant might well stand out differently in this respect. It was thought that the same interdependence between the variables as was found earlier, could not be maintained in its vicinity, althought it would be valid in the conditions of free migration in Northern Europe. Conditions in London and its surroundings are »manipulated» by the work of officials of the National Planning and such organizations. When conditions are »adapted» for the execution of the manifold social *et. al.* aims of legislation, migratory movements cannot be expected to flow in the same way as they would when free. On the other hand, it was feared that conditions in this old centre of the world trade, politics and other top level functions and in its immediate hinterland would clearly have become stiffened and set in their ways, in view of the well-known conservatism of Britain, which would stay fully insensitive to migration.

In any case, these objections only increase the temptation to concentrate this study merely upon London. At least one could then expect a large number of valuable observations and large statistical frequencies which would give more reliability to the result, what-

ever it is. Due to this, we must give the statistics a chance to show that the considered interdependence does not describe conditions here. In case the equation (1) would after all prove to be suited also to London's field, it would have to be taken seriously.

SOURCES AND PROBLEM VARIABLES

The information in this study, concerning population changes in space and time, has been taken from the most recent statistical publications available, *i.e. The Registrar General's Statistical Review of England and Wales* for the year 1960, and *idem* for 1961. From these, we can obtain the so-called estimated population for points of time 30th June 1960 and 1961 and also for space, both based on the division by counties, in the framework of which there is a more detailed division into the smallest areal elements of population records.

For the geographical use of the above-mentioned statistics, a basic map had to be obtained to show, on a suitable scale, all those areas to which the population figures refer. The writer wishes to thank Prof. *W. R. Mead*, of University College, London, for obtaining this kind of map. Its name: *Ordnance Survey of England and Wales. Combined Index showing Civil Parishes and the Ordnance Survey Maps.*[1]

But a correspondence could not be obtained from the Ordnance Survey Index for all the units mentioned in the population statistics. For these, the most recently published atlas, the *Atlas of Britain and Northern Ireland.* (Clarendon Press, Oxford, 1963), was of assistance.

A common national grid of co-ordinates is lacking on the index map generally drawn up by counties. Because of this and partly because the study extended over an area of 16 counties, it was not practical to join so many map sheets together. For each sheet a working origin of co-ordinates was therefore selected and by calculation joined with an *ad hoc* system of co-ordinates whose origin was situated at the geographical centre of gravity of London's population for 1960. With the help of statistics, this was established as being the Elephant and Castle.

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[1] (Scale: Four Miles to One Inch). Printed and published by the Director-General of the Ordnance Survey, Chessington, Surrey, 1937 and 1953—61.

As in the earlier studies, in this one a simplification was introduced into the analysis by assuming that the field variation is isotropic, *i.e.* function only of the radial distance from the origin. Thus we have to deal with only one space dimension. This considerably simplified the problem. The said distance is determined from the map sheets by means of millimeter map surface co-ordinates referring to the common origin (Elephant and Castle). It is always possible to convert these into geographical units, whenever needed.

The handling of this material by counties is rationalized in this way, so that the population figure listed in the statistical publications by counties may be attached to the proper central-distance obtainable from the map sheet of the same county. Thus the preparation of contingency tables is greatly facilitated. However the analysis of frequency distribution is decisively eased if, in place of simple distance, we use its positive square root. We denote it by x.

CONTINGENCY TABLE

When we examine the values of population movements in both time and space, the determination of the time interval in this connection does not cause any difficulties. On the basis of the source data there is a time interval of a year. The space relationship is a different matter. We have already decided to use only one space dimension, *i.e.* the variate x just defined. Now we choose as its class limits the integers 4—23, of which the first marks the radius for the first class-limit circle on the origin, the others delimiting radii for concentric circle arcs. The last mentioned do not need to be fully closed nor uninterrupted. The centre of the first class is, of course, the origin, *i.e.* $x = 0$, the others being at points 4.5 (1.0) 22.5.

On the grounds already referred to, the contingency table is most naturally compiled by counties (*v.* Table 1). Each of these obtains its own row, the columns showing x-classes. There are 16 of the former, and 19 of the latter. The number of cells is therefore 16×19. We place two frequencies into each of these which do not remain empty. The upper frequency is for 1960, the lower for 1961. Hence, there are two cell frequencies. Both refer to the 30th June in their respective years. Thus, the rows of the table are twin rows, and the contingency table itself is $16 \times 19 \times 2$-fold.

N.B.: THE CELLS OF THIS TABLE CONTAIN TWO FREQUENCIES. THAT IN THE UPPER ROW REFERS TO 1960 WHILE THE OTHER PERTAINS TO 1961.

Class	0	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5
LON A.C. ⟹	821550	1154620	1072840	–	145470															
	804140	1156050	1072940	–	146850															
MSX ⟹				553810	722780	586480	251900	137450												
				548110	719400	576090	250070	137440												
SUR ⟹		38800	–	191770	384720	298490	200290	171030	120980	66290	121320	44230	72950							
		38990	–	188400	382250	297360	206540	176830	125120	68180	125560	45440	75130							
ESX ⟹			163310	208480	516230	177780	252410	153690	96450	84070	89950	69150	262360	27550	88430	7360	51360	23320		
			156720	202220	512540	170660	257400	159880	103920	89690	96000	70390	269880	26990	91330	7500	52130	22490		
KEN ⟹				101280	66580	333470	97330	9010	140450	–	336580	77760	52850	45280	65950	74910	25870	242640		
				102430	68320	333570	98720	8910	145250	–	337860	79890	53560	45770	68620	75810	24660	241940		
HER ⟹					41550	26540	140560	119930	208310	99730	86550	76790	6080							
					40610	27280	144760	121890	218980	105530	92510	79250	6150							
BUC ⟹									146560	78340	103650	–	69790	16680	40340	13850				
									152960	82140	111910	–	74010	16870	39730	13780				
BER ⟹									42710	–	91600	60720	118110	48820	–	86500	32820	13850		
									43320	–	97380	63800	121040	52760	–	87900	33090	14200		
SSX_E ⟹										14900	–	48630	79530	13740	326280	166150				
										15540	–	50550	80930	13690	330620	171620				
SSX_W ⟹											52150	42560	–	49190	143080	110260				
											53860	45360	–	50020	149260	112430				
BED ⟹											152890	23460	11100	77800	94880					
											169550	25740	11740	79530	97630					
HAM ⟹												81580	27190	76430	7310	21680	202400	404780	230240	107250
												78290	25650	78190	7490	23430	207350	415560	232620	112400
OXF ⟹												30140	–	44960	–	139910	34870	56230		
												31460	–	46010	–	141780	36290	56550		
SFK_W ⟹														4980	15280	24550	25230	61500		
														5600	15690	25480	25210	62220		
CAM ⟹														28390	137810	20060				
														29880	140190	20930				
WIL ⟹																		36850	132380	74920
																		37840	138940	77170

Notes:

1/ i.e. City of London, and the metropolitan boroughs Southwark, St. Pancras, Holborn, Bermondsey, Westminster, Lambeth, Finsbury, and Camberwell.

2/ " MSX: Twickenham (MB) + Heston and Isleworth (MB) + Southall (MB) = {476240 466580}.

SUR: Kingston-upon-Thames (MB) + Surbiton (MB) = {102730 98840}.

ESX: Chigwell (UD) + Dagenham (MB) = {177780 170660}.

3/ " MSX: Uxbridge (MB).

4/ " HAM: Aldershot (MB).

5/ " HAM: Hartley Wintney (RD).

6/ " ESX: Harwich (MB) + Frinton and Walton (UD) = {23320 22490}.

KEN: The urban string of Cinque Ports- and other maritime towns on the Kentish shoreline, totalling {220450 219660}.

SUMMARY:

Class	0	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5
Total	821550	1193420	1236150	1055340	1877330	1422760	942490	591110	755460	343330	1034690	555020	699960	411550	919360	665230	372550	839170	362620	182170
	804140	1195040	1229660	1041160	1869970	1404960	957490	604950	789550	361080	1084630	570170	718090	422500	940560	680660	378730	850800	371560	189570
Special groups	821550 1/					756750 2/		64620 3/				38180 4/	27190 5/					243770 6/		
	804140					736080		64210				32550	25650					242150		
Remainder	nil					666010		526490				516840	672770					595400		
	nil					668880		540740				537620	692440					608650		

Table 1. Contingency table of distribution of population in space and time, 1960 and 1961 (cf. map Fig. 3).

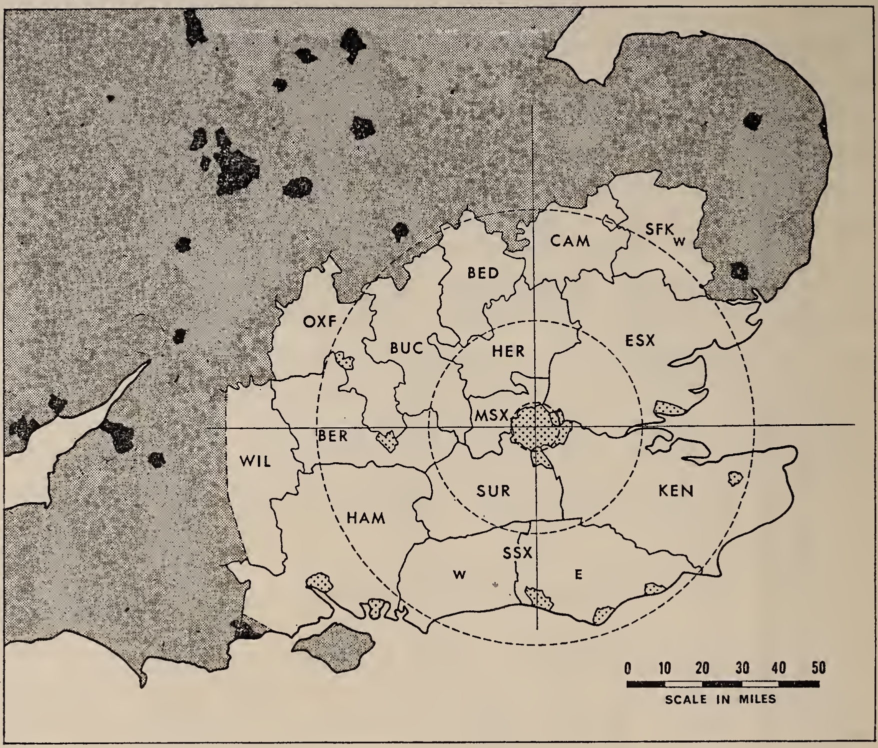

Fig. 3. The subject area of this study

It must be specially noticed that the body of the table represents information from an areal continuum. Let us call it a *field.* How it is geographically determined can be seen from Fig. 3. It cannot be claimed that definitive boundaries of London's field for 1960 and 1961 are presented by it, but it does limit the area within which we examine the suitability of Eq. (1) for describing the change of population in the vicinity of London.

Let it be emphasized that nothing has been omitted from the frame of the table. Not until enough data was collected did a brief inspection of its frequency-distribution suffice to point out all evidently inconsistent class-frequencies. Thus the worst field disturbances could be pinpointed for more detailed inspection and an eventual pulling apart.

In such a wide field as this, there are of course places whose response to the common stimulus is essentially different from that of others. In this case the function of the exceptional places may be different and so its effect on migration may be the opposite of that elsewhere. Depending upon whether this kind of field value is exceptionally negative or positive, we can call it, repectively, *sink* or *source*. In both cases it is a special point which may comprise a total frequency class, perhaps even several of them, or it may only be part of a class. In the latter case it is found, as has been said, by examining the part-frequencies.

The special points and the groups formed from them have been shown, explained, and pulled out from the class frequencies at the foot of the columns of our contingency table. In these cases, the remainder forms an adjusted first order frequency. These adjustments have been made as sparingly as possible.

In connection with the table, it must be mentioned further, that its grand total = $\{16{,}281{,}260 \quad 16{,}465{,}270\}$, Total spec. groups = $\{1{,}952{,}060 \quad 1{,}904{,}780\}$ with the remainder = $\{14{,}329{,}200 \quad 14{,}560{,}490\}$. The last mentioned making 88.2 per cent of the grand total.

RELATIVE RATE OF POPULATION CHANGE

Observed values

Applying the fact that

$$\frac{1}{P}\frac{\mathrm{d}P}{\mathrm{d}t} = \frac{\mathrm{d}}{\mathrm{d}t}\,(\ln P),$$

the statistics at the bottom of Table 1 give us the average value for the relative annual rate of population change as the difference

$$y = \ln P_{61} - \ln P_{60}. \qquad (2)$$

It is, however, more convenient to use y values expressed as thousandths. Consequently, they are denoted by Y, whereby $Y = 10^3\ (y)$. Its values are marked in Table 2, and the variation of Y_{obs} in relation to x is presented in Fig. 4.

Table 2. Assessing the deviations of observed values from those given by Eq. (3).

x	Y obs.	Y exp.	Dev	Dev²/Exp
4.5	1.36	— 2.12		
5.5	— 5.26	— 7.03		
6.5	—13.53	— 7.55	—3.90	5.783
7.5	— 3.93	— 3.16		
8.5	4.30	5.54		
9.5	15.79	16.95		
10.5	26.71	28.81	—2.10	.153
11.5	44.14	38.81	5.33	.732
12.5	50.41	45.03	5.38	.643
13.5	47.15	46.44	0.71	.011
14.5	39.42	43.12	—3.70	.318
15.5	28.82	36.25	—7.43	1.523
16.5	26.26	27.83	—1.57	.089
17.5	22.80	20.22	2.58	.329
18.5	22.93	15.58	7.35	3.467
19.5	16.45	15.41	1.04	.070
20.5	22.01	20.15	1.86	.172
21.5	24.35	29.10	—4.75	.775
22.5	39.82	40.62	—0.80	.016
	410.00	410.00	0.00	14.081

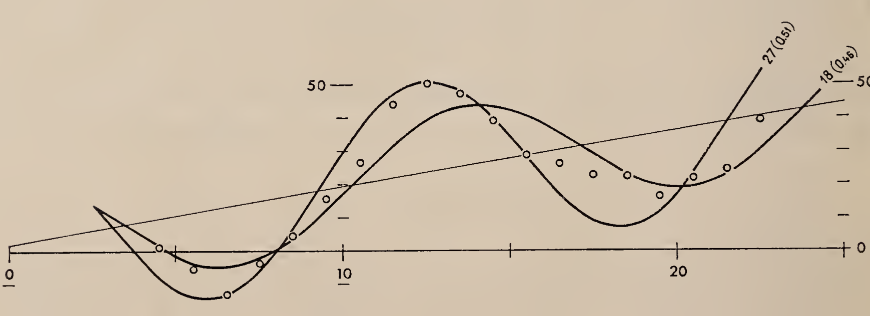

Fig. 4. 88 per cent confidence limits for the relative rate of population change.

Theoretical Y values

Two cosine curves have been drawn in Fig. 4 so that the observed points remain in the segments between them. In this way these curves form confidence limits within which roughly 88 per cent (see the previous section) of observed field frequencies were found to fall. We can thus say that the curves are confidence limits corresponding to a confidence coefficient of 0.88.

It can therefore be considered almost certain that the variation mentioned can effectively be described by a cosine curve with an appropriate intermediary march. With reference to Eq. (1), it is now possible to estimate, merely by inspection of Fig. 2, the rough values of the parameters and to write the equation

$$Y = 2.0 + 1.7\ x + 22.0\ \cos\ (0.485\ x).$$

The method of least squares gives the parameters only slightly diverging from this. In fact, we obtain

$$Y = 2.207 + 1.764\ x + 21.227\ \cos\ (0.486\ x). \tag{3}$$

The theoretical or expected Y values given by their equation are shown in Table 2. The difference of the observed and the expected values are also shown in it.

To test whether these discrepancies are greater than could reasonably be attributed to chance fluctuations in the obseved data, a chi-square test is performed.

For technical reasons which are evident we first amalgamate the rows with $x < 10.0$. The ensuing routine arithmetic is also shown in the same table. The total of the last column gives us the chi-square value required. It is 14.081.

With nine degrees of freedom, the probability of so large a value of chi-square having arisen by chance is found to be $P = 0.13$ approximately. Hence the deviations from expectation can at no reasonable probability level be regarded as significant, so it is safe to conclude that the discrepancies here found can be explained by random errors. This means that Eq. (3) is found satisfactory to describe the relative rate of population change.

GRAPH OF CHANGE

In this connection the graph of Eq. (3) is presented within its observed range $0 < x < 23$ in Fig. 5. Two scales have been marked for the independent variable. The upper row of scale figures show the x-values. During the study they formed a useful provisional variate. This scale is a necessary link to the preceding tables and text.

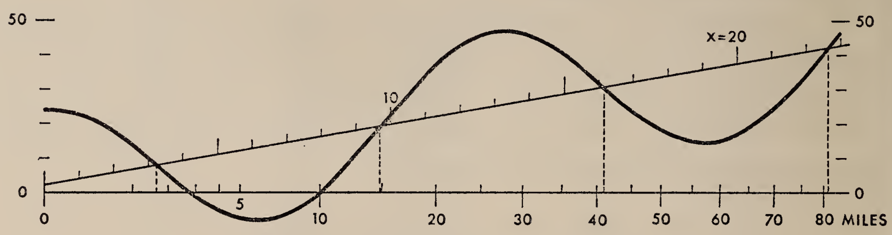

Fig. 5. The field response, $Y = Y(x)$.

The scale on the horizontal axis gives the central distances as miles. Hence, it relates the points of the curve to the conventional maps and above all to the circumstances which is attempted to describe here.

Lastly, the scale of ordinates reveals the change of Y as thousandths of actual population.

With reference to the curve, it must be borne in mind that the observed frequency corresponding to $x = 0$ reveals, as has already been shown in Table 1, a special group. With regard to its great negative deviation from the observed value, we can say in this case that the innermost part of London is, in relation to the population field, a great *sink*. It must be noted, however, that a special point cannot possibly invalidate the general law of field variation here represented.

GOODNESS OF FIT

Although the equation (3) was found satisfactory to describe the rate of population change, one has to keep in mind that the last-mentioned is essentially an abstract number of relation and intensity. That is to say, it is no count. It is no number representing the result of

a process of counting. This being the case, the merits of Eq. (3) can best be estimated by assessing frequencies that are pure counts instead of relative frequencies.

From Eq. (2) we have

Table 3. Goodness of fit. Closeness of frequencies implied by the curve to those obtained as data.

x	Home Population as at 30th June 1961 (thousands) Observed	Expected	Dev.	Dev./Exp. = ξ	χ^2
4.5	1195.04	1191.02	4.02	0.00338	0.0136
5.5	1229.66	1227.63	2.03	0.00165	0.0033
6.5	1041.16	1047.52	—6.36	—0.00607	0.0386
7.5	1869.97	1871.63	—1.66	—0.00089	0.0015
8.5	666.88	669.78	—0.90	—0.00134	0.0012
9.5	957.49	958.71	—1.22	—0.00127	0.0015
10.5	540.74	541.94	—1.20	—0.00221	0.0026
11.5	789.55	785.45	4.10	0.00522	0.0214
12.5	361.08	359.18	1.90	0.00529	0.0100
13.5	1084.63	1084.00	0.63	0.00058	0.0004
14.5	537.62	539.67	—2.05	—0.00380	0.0078
15.5	692.44	697.68	—5.24	—0.00750	0.0393
16.5	422.50	423.21	—0.71	—0.00168	0.0012
17.5	940.56	938.24	2.32	0.00247	0.0057
18.5	680.66	675.75	4.91	0.00727	0.0357
19.5	378.73	378.38	0.35	0.00092	0.0003
20.5	680.65	607.59	1.06	0.00174	0.0018
21.5	371.56	373.37	—1.81	—0.00485	0.0088
22.5	189.57	189.74	—0.17	—0.00090	0.0002
	14560.49	14560.49	0.00		0.1949

Med (ξ) = —0.00089
m.d. = 0.00225
$\sigma\xi$ = 0.00381

$$P_{61} = P_{60}\ e^{y}.$$

With $y = 10^{-3}$ (Y), and the last-mentioned given by Eq. (1), the left member remaining, represents theoretical values of P_{61}. The observed values were already shown in Table 1.

Table 3 compares the corresponding, observed and expected frequencies for 1961. This is a preliminary to a test of the goodness of fit. In this case, the arithmetic is quite the same as in the former table. This time, however, the Dev/Exp values have also been written in.

The total of the last column, 0.1949, shows a very small χ^2 value, and therefore an excellent fit. In considering it we take no heed of probability points of view, since we are assessing the closeness of frequencies implied by the curve to those obtained as data, not the probability that the curve represents a population from which the observed values were derived at random.

With reference to the relative deviations Dev/Exp, we find that their median is —0.00089, while the mean deviation from it is 0.00225, or roughly 0.2 per cent of the expectation, whereas the standard deviation from it, is 0.00381, or nearly 0.4 per cent of the expected value. Throughout this there is satisfactory accuracy, but it would certainly be too good to be true if obtained by estimating, *i.e.* when using an *a priori* conceived y.

GEOGRAPHY OF CHANGE

It can therefore be seen that the examination made above of the observed and theoretical values showed that equation (1) was suitable as to its form, and equation (3) had also the coefficients to make it a plausible descriptor of the subject variation. On the basis of this, it is reasonable to consider this interdependence also geographically. Certainly this will become more clear on the traditional basis of a map. For doing this we substitute in equation (3) $x = 2.52 \sqrt{(M)}$, wherein M denotes miles. Thus transformed, equation (3) gives the Y values expressed as a function of the radial miles-distance from the centre of London. This dependence is shown in Fig. 6.

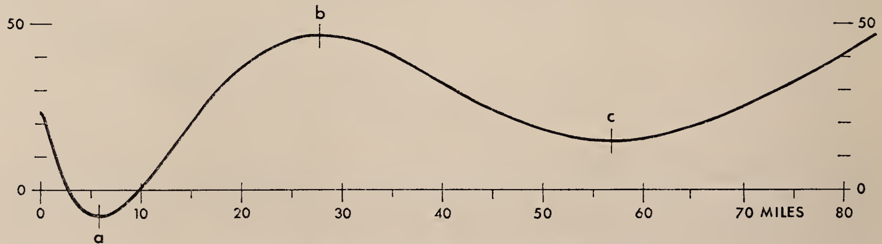

Fig. 6. The geographical field response.

Particularly in this connection we can agree that the theoretical variation in Fig. 6 actually is the response of the field to the present stimulus. These terms borrowed from biology are especially suitable in this context. We do not dwell upon the stimulus here in more detail than realizing that it is essentially a field phenomenon because the response is the most important characteristic of the field. In biology, the intensity of stimulus is more often than not, found out from the resulting response. Here also, the strength of stimulus is expressed in terms of the magnitude of the response it produces and makes measurable as the rate of local population change.

But let us return to Fig. 6. In it one cannot escape noticing the steepness of the gradient in the vicinity of the centre. Especially conspicuous is the wave crest at $x = 0$ because the corresponding observed value deviates significantly from it. Despite this fact, Y is still satisfactorily describing the response in the field elsewhere. In fact, one may suppose that the population change would even in this point have agreed with the theory, had there not been some obstacles preventing it from that. London is, as has been said, a special case, a sink, in which the deviation from expectation is significantly negative. In this particular case there is between the observation (— 21.46) and theory (+ 23.43) a gap which must be interpreted as tension. We cannot attempt to explain it in this connection, although we shall return to it. It may be mentioned, however, that the writer has not come across such an anomaly on the part of the centre in any of his previous studies.

For the urban and transport geographer especially, it is impossible not to notice the 3—10 mile interval in Figs. 5 and 6, because it forms a zone in which the change in population is negative. Such a zone is of course indicating conditions of a certain kind. In London, these conditions are found much closer to the centre than has been shown for Oslo, Stockholm and Helsinki.

The appearance of such a zone at a certain distance from the centre has been found fairly common. The distance of this kind of trough is, therefore, one of the most noteworthy features of the field response. The following crest and the outer trough are other manifest landmarks directly connected with the form of the response. Therefore, the crests and troughs, *i.e.* the extreme values of the variation are such points.

These extreme values have been marked on the cartogram in Fig. 3. The origin with $x = 0$ is shown by the crossing axes. Other benchmarks denoted in Fig. 6 with *a, b,* and *c,* appear in Fig. 3 as dashed circles. It may be mentioned that the circle labeled with *a* coincides with the limits of London A. C. Together with Fig. 6 these isolines give a picture of the topography of the field response.

When one examines the said circles, it comes to one's mind that they are too regular to describe the subject variation. But they do not try to be more than approximate in describing geographical distribution. That they are now circles is due to the simplifying assumption of isotropic distribution which has, in fact, greatly facilitated the present study. It has been helpful in laying the foundation from which one can safely proceed in the unfolding of more detailed features of this complicated phenomenon.

CONCLUSION

The living area of more than 16 million people studied here offered data in an amount which filled the cells of a $16 \times 19 \times 2$-fold contingency table, so that its smallest frequency comprised 5 000 people. The picture of the resulting frequency distribution has thus been built upon ample statistical evidence.

At the beginning of this work, it might have been expected that in a field like this, everything would be on a much larger and more powerful scale than in the places studied earlier, of which Oslo, Stockholm and Helsinki fields were the largest. There were about a million people in each of them. Yet their radiuses were the same class as London's in length, but in none of these was there room for a full wave length, whereas London's field extends over 1 ¾ or almost two wave lengths. The amplitude of the variation was greater in the fields of the northern capitals. In case of Stockholm it was 71 altogether, while in London it was only 21 per thousand. On the other hand, it was easy in the case of London to form a double amount of x classes and there could safely have been even more of these. But this amount was sufficient to show satisfactorily that equation (1) is suited also to the London field. It is a solution to the problem which this study set out to explain.

Before a full stop can be written, however, it should be observed that in the earlier cases the distribution had followed sometimes a sine, at others a cosine-curve. Tampere, where the writer has over a long period of time, carried out a study of the alternative of cosine and sine, was characterized in its earliest phases by a cosine form. Later, at a time when transport facilities greatly improved, the booming industry needed much labour force and the town became an important commercial centre, the distribution suddenly took on a sine form (AJO 1961 b). If it were concluded on the basis of this that the sine form comprised a stage of development when centres were built up as, for example, was the case for the North European capitals just mentioned, it could have also been concluded that this was true of London.

However, it is not. London's curve is a clear cosine and includes so many observed points that one cannot arrive to another conclusion. In addition, the most central point in London's field displays the greatest deviation, which is unique in the chain of observations made up till now. London is therefore different. But it is very richly yielding and a most intriguing subject for extended study.

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LONDON'S FIELD RESPONSE
II

BY

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HELSINKI
1964

Vammala 1964, Vammalan Kirjapaino Oy.

LONDON'S FIELD RESPONSE

II

The most important point in the conclusions arrived at in a previous paper on London's field response was that the straight-line-and-sinusoid response applies also in London's field (AJO 1964). Less important but so much the more surprising, was the point that the staked-out sinusoid took the cosine shape against odds in favor of the sine. The fact that roughly 90 per cent of observed frequencies were found to fall within confidence limits of cosines was, however, not to be disregarded. This intrigued the writer and was also the direct incentive to continue the study which has borne fruit in this paper.

That first approach was mainly tentative, carried out on a broad basis and concerning the population in bulk. The present study tries among other things to find out the correctness or erroneousness of the interesting sine-cosine alternative. To this end the renewed approach is based on an analysis which resolves the subject material into constituent elements with a view to discovering their partial responses. A subsequent synthesis will either confirm, refute or replace the preliminary finding.

Furthermore, an analysis of the collected material may also in other respects throw welcome light on the field phenomena of many population processes.

Review of the field population by categories of local authority

Being a continuation of the paper just mentioned, the present study is based on the same primary material. Now we need only mention the main source: *The Registrar General's Statistical Review of England and Wales for the Year* 1960, and *idem* for 1961. Unnecessary reprinting of published statistics will be avoided in order to save space and not to annoy the reader. Instead, care will be taken to present statistics concisely and, it is hoped, in digestible form.

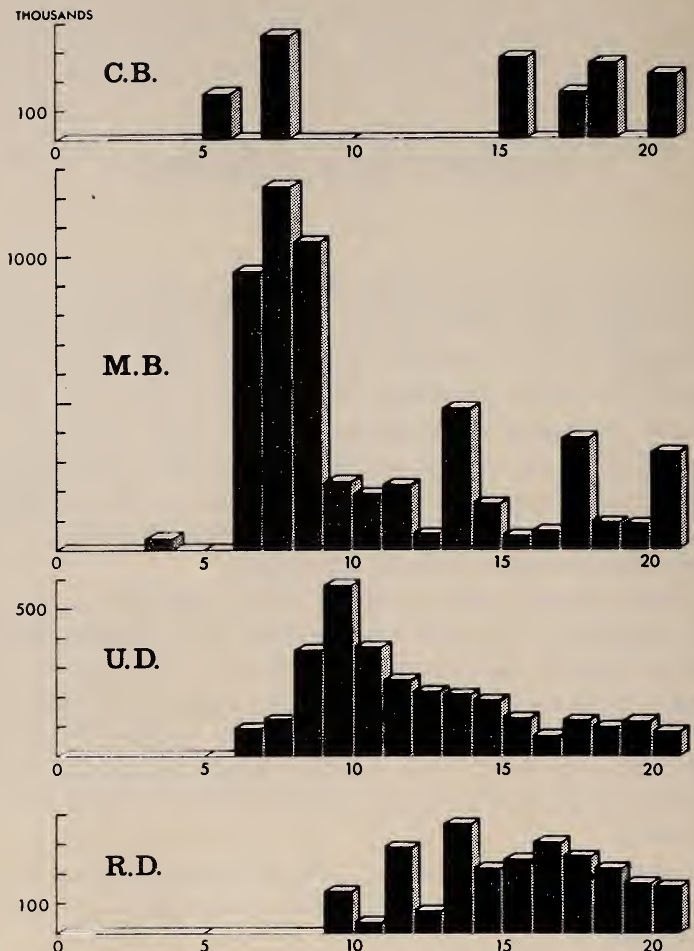

Figure 1. Review of population frequencies in x-classes and by category of administrative area. For data, see Table 1.

There is a Chinese proverb maintaining that one picture is worth ten thousand words. Although an exaggeration, this may be partly true. This is why we are including Figs. 1, 2, and 3, which afford a review of the population, its annual growth, and relative rates of change distributed into the x-classes and on the different levels in the graded order of administrative divisions. x is the field variate. It is proportional to the positive square root of the distance from the zero set at *Elephant and Castle,* London. As to the levels mentioned, the highest

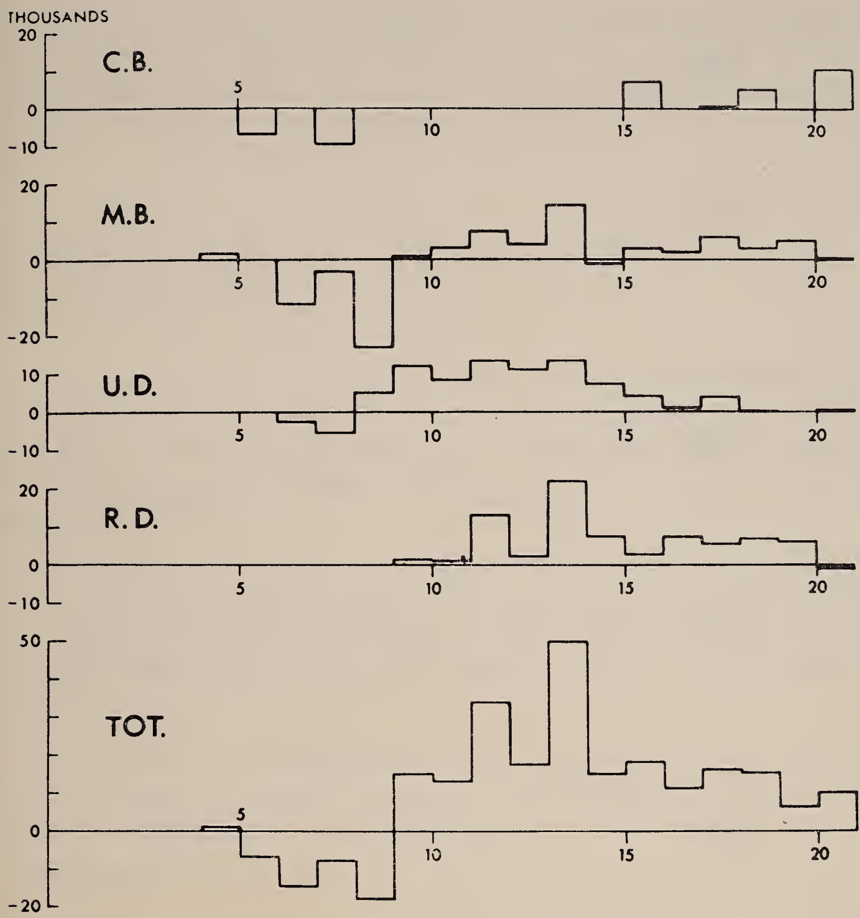

Figure 2. Net absolute change of population in x-classes and by category of administrative area. Data from Table 1.

of them consists of the City of London and the Metropolitan Boroughs (Met. B.). The others are given in order: the County Boroughs (C.B.), Municipal Boroughs (M.B.), Urban Districts (U.D.), and Rural Districts (R.D.). The symbols in brackets are those used by the Registrar General.

Later on, attention will be drawn to the crucial points in the said pictures. Now, before we go on, we must glance at the data used in preparing the graphs. Emphasis is laid on the fact that it was not

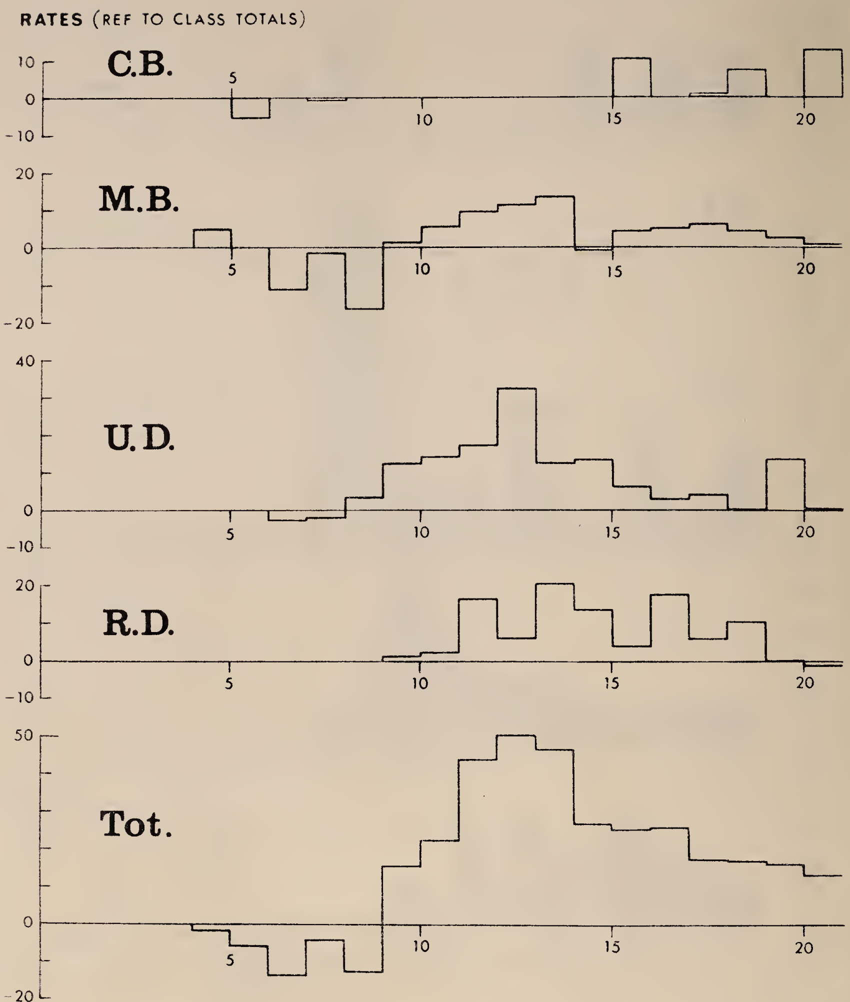

Figure 3. Net rates of population change in x-classes and categories of administrative areas. Data from Table 1.

considered necessary to carry out a preparatory sieving or processing of the statistical material, once the applying of sinusoids was established.

The same bulk of statistical figures refers here to the same field as in the preceding paper. But the grouping of the data is different. In the shuffling and reshuffling, some inconsistencies were discovered both in the primary material and in the tables compiled from it for the

present as well as for the previous study. Fortunately, the inconsistencies found were so small that they could be disregarded and drowned in the margin of error allowed at the statistical source. With these words we introduce Tables 1 and 2.

Birth and death rates
Idem for excess of births

Birth and death rates are measures of important demographic processer and, consequently, also outstanding field phenomena. Considering their observed values against the independent field variate, x, one cannot escape noticing that they stake out a curve with a characteristic wave form.

With a view to practical curve fitting, the familiar sinusoid seems most promising when the fitting involves the side condition of a common wave-lenght for the curves of birth rate (B), death rate (D), and their difference (B-D) representing the excess of births or the net rate of natural increase.

Most obvious is the march of the curve to be fitted in case of B-D. The actual fitting is in this case carried out by inspection, because more accurate results are not required at present.

Referring to Fig. 4 we have

$$B = 17.9 + 3.1 \sin (0.64 x) \qquad (1)$$

$$D = 7.2 + 0.3 x - 1.9 \sin (0.64 x) \qquad (2)$$

$$B\text{-}D = 10.7 - 0.3 x + 5.0 \sin (0.64 x) \qquad (3)$$

Of these equations, (1) differs from the others in the absence of the linear first degree term. This makes the portion of the B-curve shown in Fig. 4 symmetrical about $x = 12.25$. The constructive axis of the curce remains horizontal. We shall return to this, its characteristic feature, shortly.

Table. 1. Population for the years 1960 and 1961 by x-classes, and category of administrative areas. The upper rows give the figures for 1960, the lower ones for 1961. Source: v. Text.

x	Met.B.	C.B.	M.B.	U.D.	R.D.	Tot
3.0	88690					88690
	86270					86270
3.5	732860					732860
	717870					717870
4.5	1154620		38800			1193420
	1156050		38990			1195040
5.5	1072840	163310				1236150
	1072940	156720				1229660
6.5			959350	95990		1055340
			947710	93450		1041160
7.5	145470	358850	1242360	130650		1877330
	146850	357940	1239620	125560		1869970
8.5			1066310	356450		1422760
			1043390	361570		1404960
9.5			229020	574020	139450	942490
			230190	586150	141150	957490
10.5			190190	366430	34870	591490
			193470	374990	36490	604950
11.5			218230	255480	281750	755460
			225760	269060	294730	789550
12.5			51570	217720	74040	343330
			55700	229160	76220	361080
13.5			470620	205390	358680	1034690
			484970	218940	380720	1084630
14.5			155300	183850	215870	555020
			155040	191560	223570	570170
15.5		278230	45370	124830	251530	699960
		285660	48410	129620	254400	718090
16.5			60030	70160	303630	433820
			62280	71560	311470	445310
17.5		160860	377480	124840	259850	923030
		161690	383600	128840	265390	939320
18.5		258120	89300	99410	218390	665220
		263210	92630	99470	225350	676660
19.5			83950	115440	173170	372560
			84880	120670	173180	378730
20.5		217520	331750	86490	166560	802320
		227930	332450	86940	165640	812960

Table 2. Totals of live births and deaths by x-classes and category of administrative area for the statistical year 30th June 1960—61. Source: v. text.

Category:	Met.B.		C.B.		M.B.		U.D.		R.D.		Total		Mils	
Class	B	D	B	D	B	D	B	D	B	D	B	D	B	D
3.0	1698	1248	—	—	—	—	—	—	—	—	1698	1248	19.4	14.3
3.5	13418	8267	—	—	—	—	—	—	—	—	13418	8267	18.5	11.4
4.5	22105	14855	—	—	529	490	—	—	—	—	22634	15345	19.0	12.8
5.5	20653	11929	3011	1741	—	—	—	—	—	—	23664	13670	19.2	11.1
6.5	—	—	—	—	16724	11246	1421	1053	—	—	18145	12299	17.3	11.7
7.5	2178	1616	5915	4303	17983	13843	1611	1457	—	—	27687	21219	14.8	11.3
8.5	—	—	—	—	15517	11319	5516	3453	—	—	21033	14772	14.9	10.5
9.5	—	—	—	—	3626	2444	10395	5042	2530	1348	16551	8834	17.4	9.3
10.5	—	—	—	—	3270	2118	6651	3256	725	348	10646	5722	17.8	9.6
11.5	—	—	—	—	4340	2151	5284	2487	5060	2851	14684	7489	19.0	9.7
12.5	—	—	—	—	1188	408	4906	2109	1304	669	7398	3186	21.0	9.0
13.5	—	—	—	—	9070	5258	4673	1897	7545	3615	21288	10770	20.1	10.2
14.5	—	—	—	—	2950	1749	3892	1930	3879	2534	10721	6213	19.1	11.1
15.5	—	—	4548	3684	902	579	2243	1615	4003	3105	11696	8983	16.5	12.7
16.5	—	—	—	—	1149	822	1258	810	5537	3649	7944	5281	18.1	12.0
17.5	—	—	2375	2500	5564	5878	1878	1776	3940	3893	13757	14047	14.8	15.1
18.5	—	—	3648	3916	1308	1441	1397	1630	3990	2350	10343	9337	15.4	13.9
19.5	—	—	—	—	1453	1127	2430	1362	3055	2084	6938	4573	18.7	12.6
20.5	—	—	3727	3009	5774	4122	1490	1087	2892	1813	13883	10031	17.2	12.4

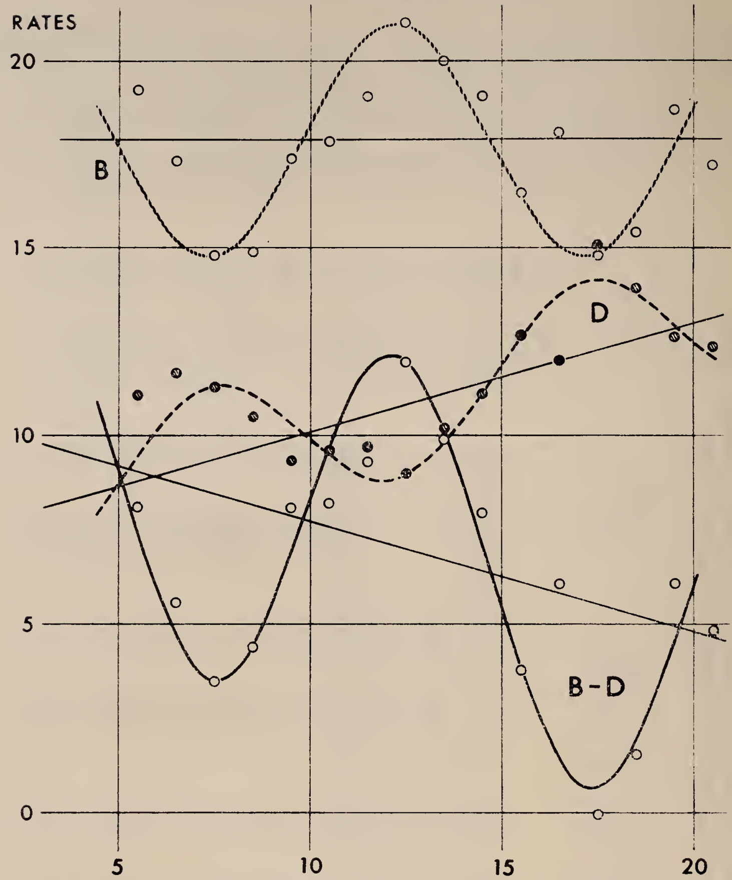

Figure 4. Sine-curves fitted to Table 2 data of birth and death rates and their difference, the net natural increase, in x-classes.

Rates of
Net change of population
and Net migration

Net change of population comprises the net rate of natural increase and the net rate of migration. We therefore expect the sinusoids shown in Fig. 5 to possess the same wave-length as those already dealt with.

In fact, the graph of net change of population (N C) as shown in Fig. 5 displays a rather satisfactory fit to the data within the range up to $x = 15$, after which the divergences become greater. In this case we may write

$$\text{N C} = -7.9 + 2.4\ x + 27\ \sin\ (0.64\ x) \qquad (4)$$

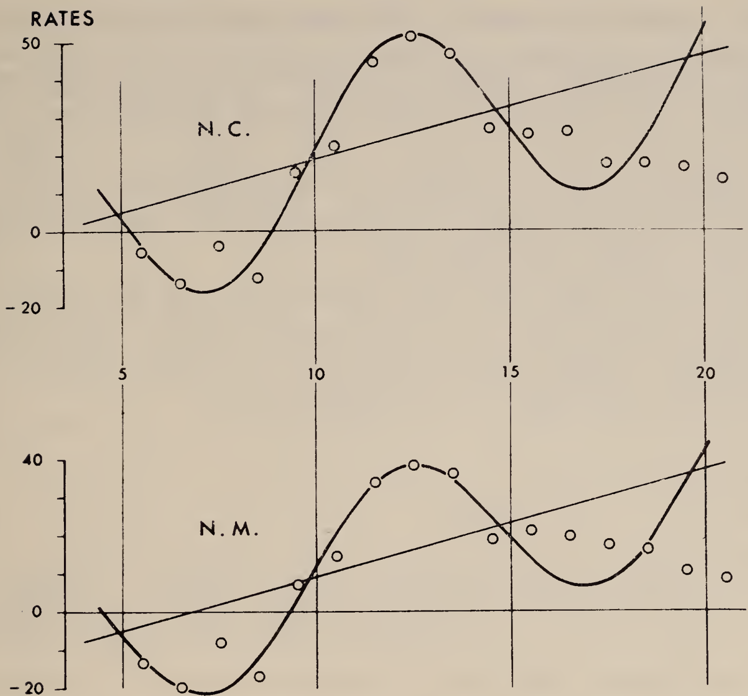

Figure 5. Sine curves fitted to the plots on x-values of the rates of net change of population (NC) and net migration (NM). The last mentioned is obtained by subtracting the net rate of natural increase from (NC). Observe the different scales of ordinates in Figs. 4 and 5.

Subtracting the net rate of natural increase given by (3), this leaves us with the deduced net rate of migration,

$$\mathrm{N\ M} = -18.6 + 2.7\ x + 22\ \sin\ (0.64\ x) \quad (5)$$

The cos vs. sin alternative

This approach could profit from the previous study, which focused on finding out whether the field response of London could be described by a sinusoid, which is a common label for cosine and sine curves. In view of its pilot character, the study highlighted the rates of gross change of population within a tentative field of London. The result was affirmative as regards the sinusoids. In particular it indicated the cosine alternative for the best fit to the given points. This result had to be taken at its face value in the absence of other clues.

The promising outcome of the said essay stimulated continued examination of population processes in London's field. This time an analysis of available material was tried. In this way the observed numbers were multiplied, the fitting points became five-fold, and there arose additional fitting constraints which all added up to more facts upon which to build the conclusions. The syntheses of these minor building blocks arrange into an additive set of curves, each one consisting of a linear element and a sine term.

Sinusoids thus apply also in the case of London. So far the conclusion of the pilot study is still correct. The cosine, however, was an apparent and possible solution, whereas the sine, on the present evidence, turns out to be the real answer. Thus: sine, after all!

General form of the response

The response to field excitement cannot possibly be unique. We have already specified five of them in the respective equations given above. But they do not tell the whole story. Far from it. We sorely miss expressions for the rates of in-and-out migration. But there are innumerable other aspects not touched upon. Anyway, we can generalize the results included in the equations just given.

The equations (1) through (5) are conspicuously similar in form. In fact, one could write for them jointly

$$y_n = a_n + b_n x + R_n \left(\begin{matrix} \cos \\ \sin \end{matrix} \quad w_n x \right) \tag{6}$$

As is seen, this equation includes the cosine/sine alternative and leaves room for an unlimited number of similar expressions. Therefore (6) is a common expression for a whole family of responses.

The differential equation of this family is even more general and compact in form than (6). We have

$$(1/w^2)y'' + y = a + bx \tag{7}$$

By way of conspicuous analogy with physical field theories, this equation at once gives the impression of a field with distributed internal excitation. The full solution of (7) is the field response

$$y = a + bx + A \cos (wx) + B \sin (wx) \quad (8)$$

expressed as the sum of its components, of which the particular integral is linear in x whereas the complementary function is the sinusoidal component.

In view of the linearity and the analogy already mentioned, the particular integral is identified with the active component of the field excitation. That it is in reality a component of the response is of little consequence. Similar substitutions are rather common in biological essays, simply for expediency. Here too, we need an input quantity, and there is no doubt about the justification off equating a component of the excitation with a corresponding and observable component of the response. The particular integral is specially suitable because of its linearity. Also it is worth noticing that the field response (8) is a single-valued function of the linear excitation, whereas the converse is not true. So much for the particular integral.

The sinusoidal component of the response is in this connexion primarily regarded as the birth rate or a quantity proportional to it. This point will be discussed in the next section.

The responses in terms of centrality (x) and birth rate (B)

From Equation (1) we have

$$\sin (wx) = (B - 17.9)/3.1$$

On entering this in Eq. (4), we find for the change of population

$$NC = -7.9 + 2.4\ x + 27\ [(B - 17.9)/3.1] \quad (9)$$

which may be written

$$NC = -163.8 + 2.4\ x + 8.71\ B$$

Similarly (2), (3), and (5) may be written as (10)

$$\begin{aligned} D &= 18.2 + 0.3\ x - 0.61\ B \\ B\text{-}D &= -18.2 - 0.3\ x + 1.61\ B \\ NM &= -145.6 + 2.7\ x + 7.10\ B \end{aligned}$$

These equations clearly show that each process depends on two variates, the one, x, referring to the governing centre, while the other (B) represents internal energy.

By now one has got used to allegories such as 'city lights' and 'rural escape', the latter being synonymous with the former although it is instinctively felt to be the reverse side of the coin, implying the rejection of rustic chores. Now the equations (10) explicitly mention both effects separately and precisely. This is a great step forward in understanding the mechanism of population movements.

The coefficients of x and B are the weights by wich the said variates contribute to the actual process. In view of this, the given equations throw new and welcome light on the mechanism of the process considered.

Estimating vital statistics

Each of the equations (10) is a simple linear expression in x and B, the coordinates of a point on the surface of births. Because of this, and because they are the most easily obtainable data x an B are particularly appropriate independent variables for the equations (10), which might well be used as estimators for statistics either unavailable or published after a considerable time-lag.

It must, however, be emphasized that the accuracy of these equations cannot be greater than the approximations from which they are deduced. Neither are they valid in other conditions.

Because the coincidence of observed and fitted, *i.e.* expected, values in Figs. 4 and 5 is nothing like complete, it would be rather optimistic to expect top-class estimates from Eqq. (10).

To form an idea of this, we are going to find estimates of NC for the classes $x = 5.5$ (1.0) 18.5. What we get is Table 3. A glance at the columns makes it clear that the observed and estimated NC values are correlated. Two classes at each end of the columns, however, display less good correspondence. Those classes omitted, we find for the correlation coefficient $r = +0.933$. Consequently, $r^2 = 0.870$, and $t = r\,[(n-2)/(1-r^2)]^{1/2} = 6.70 > 3.169$.*) The correlation is thus strong, and it must be pointed out that more often than not we are forced to use estimates which fall far for short of the figures just arrived at.

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*) 1 per cent level, 10 degrees of freedom.

Table 3. Juxtaposition of observed and estimated NC values.

Classes (integers)	NC obs.	NC est.	Dev.
5	— 5.3	16.5	(—21.8)
6	—13.5	2.6	(—16.1)
7	— 3.9	—17.1	13.2
8	—12.6	—13.8	1.2
9	15.8	10.7	5.1
10	22.5	16.4	6.1
11	44.1	29.4	14.7
12	50.4	49.1	1.3
13	47.1	43.6	3.5
14	26.9	37.0	—10.1
15	25.6	17.1	8.5
16	26.1	33.2	— 7.1
17	17.5	6.8	10.7
18	22.9	14.5	8.4
19	16.4	43.9	(—27.5)
20	13.2	35.1	(—21.9)

Figs. 1 and 4 show that the maximum concentration of population in both county and municipal boroughs occurs at $x = 7.5$ coincidently with the birth rate minimum corresponding to the sine argument $3\ \pi/2$. This justifies putting $1.5\ \mathrm{w} = 3\ \pi/2$ whence follows $\mathrm{w} = 0.63$. The actual curve-fitting done in connexion with Figs. 4 and 5, however, locates the said $3\ \pi/2$-point at $x = 7.35$. The corresponding $\mathrm{w} = 0.64$ indicates rather good agreement between observation and theory. Similarly, we could have chosen from Fig. 3 the maximum rate of population change or the modal point of frequency distribution in the category of urban districts. Both rates, being coincident with the birth rate maximum (Fig. 4) corresponding to the sine argument $5\ \pi/2$, would have caused letting $12.5\ \mathrm{w} = 5\ \pi/2$ with the same 0.63 resulting.

It is evident that the estimate of w is also influenced by the class width chosen. Furthermore, being derived from sample conditions, it is subject to random variation. For these reasons the estimate of w possibly requires some adjustment, as in the preceding paragraph.

Synthetic review

Reviewing the field responses and their graphs, it is convenient to repeat that the straight-line component was identified with the field excitation or, let us say, the field strength. Likewise it was pointed out that the field response or, for shortness, the response, is a single-valued function of the field strength, whereas the converse is not true. We may now expand this statement by noticing that the response is a single-valued function of x and, ultimately, of the central distance, but not vice-versa. This circumstance may be referred to by saying that the response is *distance controlled.*

Retransforming our argument x into natural distance brings the survey onto geographical terra firma. Distance is basic to geography, because only when description is set forth in terms of distance, has the geographer a yardstick usable for explanation. To show this, the march of NC is graphed against distance in miles, in Fig. 6.

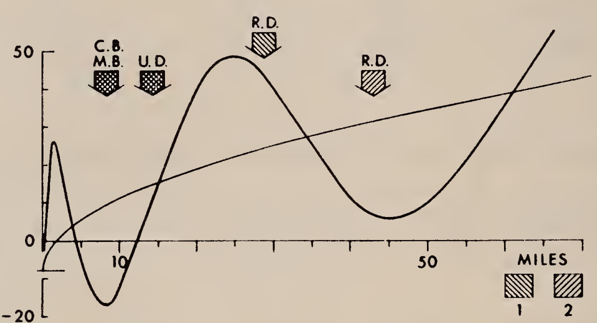


Figure 6. Rate of net change of population (NC) in dependence on distance in miles from London. The arrows fix the positions of max concentration within categories shown by respective symbols. Hatchings: 1 = max concentration of inhabitants; 2 = max number of administrative areas.

The first component of the right member of Eq. (4), the constant term, marks the value of NC in the very centre, at zero distance. It also positions the axis (a fragment of which is shown in Fig. 6) of the parabola representing the second term. According to the convention pointed out earlier, this parabola describes the field strength. To this has been added the transformed third term, whose sine oscillation has in the transformation been badly distorted. In this successive adding up of all three terms we have constructed the locus of NC. It is the full response.

When considering field responses one cannot disregard the central places. They are, by definition, active field elements, which means that their location and girth must be of consequence to the shape taken by the response. Fig. 6, showing in terms of distance the march of both field strength and response, has therefore been completed with sign-arrows fixing the positions of maximum concentration within the various categories of administrative areas. The kind of concentration is indicated by hatching. Hatching 1 denotes max. concentration of inhabitants, hatching 2 *idem* for the number of administrative areas, while cross-hatching signifies simultaneous occurrence of both.

Before going on, this is the proper moment to introduce a map showing the geographical distribution of the various categories of administrative areas whose symbols in the British nomenclature might otherwise be bewildering for many a reader. This is done in Fig. 7.*

As to the individual categories, the most central of them, the Metropolitan boroughs, were left without an arrow, as it was not considered absolutely necessary and in order not to overload the picture. Instead, the reader is referred to Table 1. It is useful to compare Fig. 6 with Fig. 1.

Taking for granted that the City of London as well as the Metropolitan boroughs represent the topmost class of central places, it is evident that C.B. and M.B. form the combined second class, and U.D. the third class of central places, in the present setting.

We may thus conclude that the mode of the second class central places is located at the wave bottom in class $x = 7.5$, about 9 miles from the centre. The mode of the third class has its site at one wave-length's distance in the immediate vicinity of sin $(\mathrm{w}x) = 0$, in the class $x = 9.5$, about 15 miles from London.

Then we notice the mode of the distribution of population within the category of rural districts (R.D.). It lies in the class $x = 13.5$, at a distance of about 29 miles. The greatest number of rural districts fall three class intervals farther out, in the class $x = 16.5$, about 44 miles from London's zero point.

These observations strongly support our earlier impression that there exists a definite correspondence between the locational distances appropriate to each category of central places on the one hand, and the zero and minus max. points of the sine term on the other. One could take for granted that they are coincidental in space. On consulting

* Appended.

Table 1, it may be concluded that this applies also to the modal point of distribution of people in the metropolitan boroughs.

As far as central distances are concerned, this means that each category of central places tends to be located on a practically equidistant circle-arc. This is in complete accordance with the author's observations concerning Finnish conditions. The radii are longer in Finland than in the densely-populated surroundings of London.

The synoptic chart of the partial frequency distributions represented in Fig. 1 left one wondering whether at least some of these distributions are a mixture of distinct components. In order to try to find an answer to this point, we are going to compare the frequency distributions. To this end they are superimposed in Fig. 8. To simplify matters, the borough categories C.B. and M.B. are this time pooled, and all distributions are represented by frequency polygons. They refer to the year 1961 and make use of the data given in Table 1.

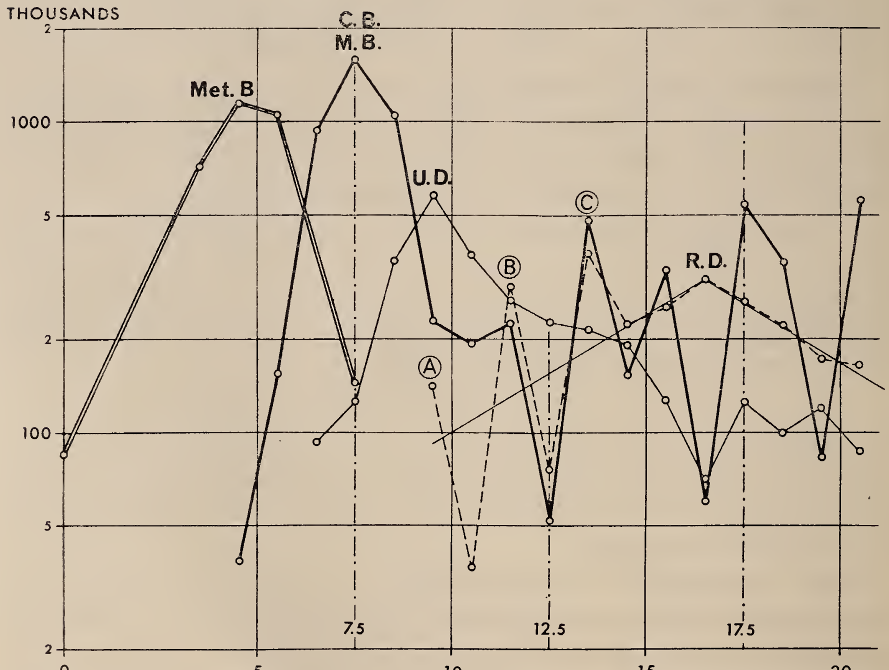


Figure 8. Summary by categories of administrative areas of population frequencies on centrality (x). Logarithmic ordinates.

The left half of the said diagram, with the distribution peaks for the first (Met.B.), second (C.B. + M.B.), and third (U.D.) class central places, gives a clear-cut picture of the distribution, whereas the peripheral part of the same graph seems at first sight to form a patternless structure of interlacing lines. We are now going to take a look at this manifold varying. It takes place in the countryside proper, *i.e.* within the range of the frequency polygon of rural districts.

The conspicuous fluctuations in the rural population frequency are smoothed out in the idealized freehand regression lines drawn in Fig. 8. In the light of this smoothing, one cannot escape noticing the contrary motion in the frequencies of rural (R.D.) and urban (U.D.) populations within the interval $9.5 \leqq x \leqq 16.5$. Within this interval the varying of U.D. frequencies is monotonic, whereas the unsmoothed R.D. frequencies carry out three outstanding oscillations, marked A, B, and C.

The frequencies belonging to the second class central places follow suit and vary in step with the above. The first (A) step, however, is sluggishly short while the second and third ones correspond closely to those of the rural districts. This does not mean only that both variates are positively correlated. In the B and C steps, i.e. with $11.5 \leqq x \leqq 14.5$, the correlation is very strong indeed. Both distributions have a common minimum at $x = 12.5$, which makes an important landmark because of the coincident birth rate maximum.

Of special interest is the fact that the maxima for the second class central places, at $x = 7.5$ and 17.5, coincide with the respective birth rate minima (*cf.* Fig. 4). It is also of consequence that the second and third classes' common minimum at $x = 16.5$ coincides with the rural districts' smoothed maximum.

These features appear also in Fig. 9. It represents each partial frequency divided by the respective class area (sq. mi.). Thus the class area which is obtained directly from the pertinent class-limits is made a common denominator. The resulting figures are not densities proper, because the frequencies and areas do not strictly correspond. Partial densities for particular categories are out of the question because the required acreages are not available.

From Fig. 9 we note with interest that the distribution of rural population begins with the peak A at $x = 9.5$, which is the location of the urban districts' mode, and at the same time the point where the frequency of the second class central places levels off to a veritable foothill (Figs. 8 and 9).

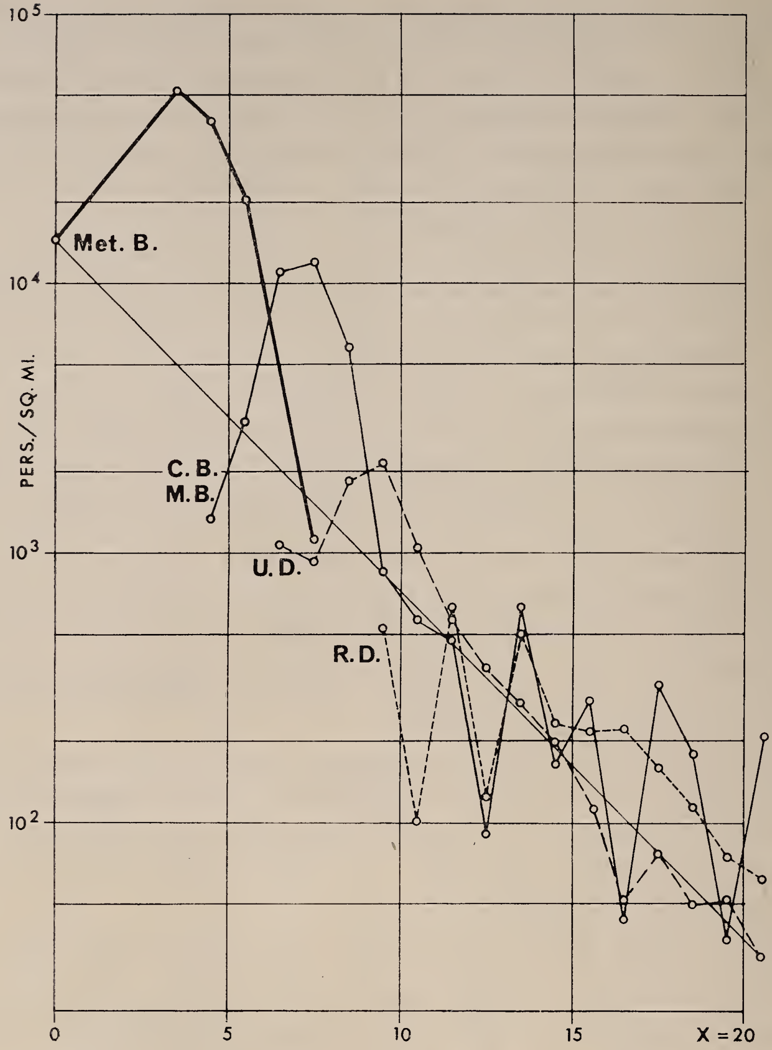


Figure 9. Population frequencies within categories of administrative areas, divided by respective class areas (sq. mi.), plotted on centrality (x). Logarithmic ordinates.

The fact that the frequency distribution of population in the second class central places extends over three particularly important x values, *viz.* $x = 7.5$, 12.5, 17.5, suggests that the subject category actually consists of three distinct types of boroughs, each type being typical of an interval or zone centered at one of the said x-values. There are

Table 4. Statistics characterizing zonal differentiation of borough-types. Zone limits given in text.

Item	Zone I	Zone II	Zone III	All three zones
	rounded off quantities			
Borough (C. B. & M. B.) population, millions	3.5	1.1	0.7	5.3
Inhabitants per borough, thousands	80	48	19	51
Zone area, sq, mi.	747	3166	8523	12436
» » » », per borough	17	138	237	121
Borough population per sq. mi. zone area	4684	347	82	425
Rate of natural increase in the borough-type, per thousand	4.2	8.2	0.8 *)	4.7

*) In 13 boroughs out of 36 the rate is negative with an average of —5.7. In one case it is —11.8.

the zones $4.5 \leqq x < 10$, $10 \leqq x < 15$, and $15 \leqq x < 20$. For shortness, let us label them I, II, and III, respectively.

Within the first zone, the number of borough-inhabitants is overwhelmingly greater than the rural population also included, while in the second zone they are nearly equal, and in the third zone the rural population preponderates. Accordingly we may call the borough types the first, second, an third *types of borough.*

To form an idea of these types, we will take a glance at some characteristic statistics given in Table 4. It shows clearly that the spatially more centrally located boroughs stand higher in the hierarchic scale of socially qualifying capacities such as the number and density of population. These very factors, *i.e.* the more central, the higher up, the more extended its base, are the literal meaning of the *central place hierarchy,* a term so popular nowadays. The types of boroughs just described are an example of it. The hierarchic order: Met.B.; C.B. & M.B.; U.D.; R.D. so clearly seen in Fig. 9 is another, even more so because the latter is the main line while the borough-types represent only a lateral branch of it.

Table 5 shows the accumulated totals of class frequencies and areas. Densities computed from these totals are, of course, averages. To be precise, they ought to be called *expanded averages,* because they are neither densities nor averages in the usual sense of the terms. However,

Table 5. Average density of population within outer class-limit of stepwise expanded area.

Upper limits x	mi.	Total Popul. ('000)	Total Area sq. mi.	Av. Density Pers/sq. mi. ('000)
3	1.4	87	6	14.5
4	2.5	813	20	40.6
5	3.9	2007	49	41.0
6	6.3	3240	101	32.1
7	8.6	4288	197	22.9
8	11.2	6162	319	19.3
9	14.2	7576	511	14.8
10	17.6	8526	779	10.9
11	19.1	9124	1141	8.0
12	22.7	9896	1616	6.1
13	26.6	10249	2226	4.6
14	30.9	11308	2994	3.8
15	35.4	11871	3945	3.2
16	40.3	12580	5107	2.5
17	45.5	13019	6509	2.0
18	51.0	13951	8181	1.7
19	56.8	14614	10156	1.4
20	63.0	14999	12469	1.2
21	69.4	15807	15156	1.0

should anybody prefer to consider densities of particular classes, he can obtain them from the totals in the same way that the economist would find the marginal cost from a pair of total outputs and their total costs. This is the procedure: Divide the difference in the total population by the difference in the total area. Although this, too, is an average, it is something other than that given in Table 5, just as the marginal costs are one thing and the average costs another. Now we are concerned with the first-mentioned averages.

An arithmetical plot of densities on miles of distance is shown in Fig. 10. Clearly, the tail of the density distribution, beyond 19.1 miles from the centre, could easily be fitted with a simple power function. With a view to extrapolating towards the centre, it is, however, reasonable and practical to have a finite intercept with the zero ordinate. Hence the exponential was chosen. Its equation and march is shown in the graph.

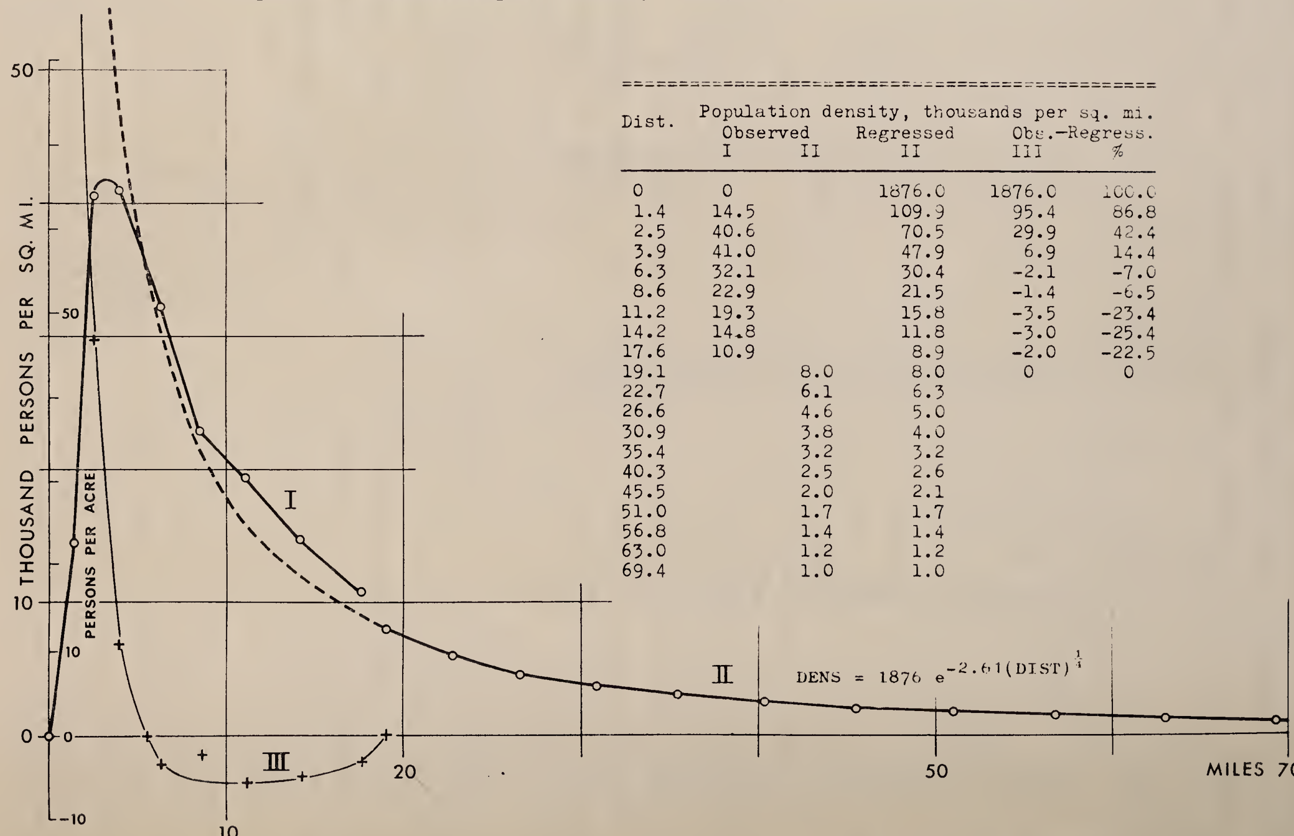
The inner part of the density curve is of a different type. The author is inclined to regard it as indicative of deviation caused by saturation, *i.e.* inability to receive and house more people, which makes the actual values fall short of their would-be magnitudes. If this is correct, one could argue that the regressed curve represents field potential of density. It might really be taken as the stimulus. At its lower levels, say below 35 thousand persons per square mile, there is no visible falling off of the actual values, or the response, from the potential. At some critical point, however, the actual density is no longer capable of coping with the potential. It falls behind, the growth ceases and turns into a definite slope downward. All this must be due to an opposing tendence, a resistance, an impedance, or whatever it may be called. Anyway, its effect is to be measured in the same units as that of the moving power, the potential. Thus it takes the dimension of density, but as an opposing force it is essentially negative.

Similarly, we postulate also positive forces which add upp to the potential. In the case of London one could suppose that the various administrative measures implied in regional and other planning might act as such boosters. In Fig. 10 the observed densities at distances of 11.2, 14.2, and 17.6 miles from the origin are an illustration of this.

We thus assume two kinds of modifying forces. Their algebraical sum with the potential density evidently counterbalances the density actually observed. Each of these three forces varies with the distance in its particular way characteristic to the corresponding functions which are graphed in Fig. 10. The modifying forces, however, are shown jointly because we need not yet analyse them separately. Nevertheless, it can be seen that the resistive modifier varies monotonically and thus in a manner everybody is instinctively willing to admit. It is the relative change of the respective gradients that matters. This fylly explains why the actual density curve is humped and has its maximum located at a distance from the centre. Evidently this conclusion helps us better to understand the peculiarities of density profiles.

Because the hierarchic landmarks seem to have as their counterparts peaks or depressions in the density variation, they appear on population maps as corresponding density ridges or trenches. Circular and other density ridges mounted by satelliting central places are shown *e.g.* on Finland's population map (*v. Atlas of Finland 1960,* maps 15—17). This phenomenon is quite outstanding around the more important maritime cities. In some cases such position line circles of different orders may

Figure 10. Arithmetical plot of density averages on miles of central distance.



Dist.	Population density, thousands per sq. mi. Observed I	Observed II	Regressed II	Obs.–Regress. III	Obs.–Regress. %
0	0		1876.0	1876.0	100.0
1.4	14.5		109.9	95.4	86.8
2.5	40.6		70.5	29.9	42.4
3.9	41.0		47.9	6.9	14.4
6.3	32.1		30.4	-2.1	-7.0
8.6	22.9		21.5	-1.4	-6.5
11.2	19.3		15.8	-3.5	-23.4
14.2	14.8		11.8	-3.0	-25.4
17.6	10.9		8.9	-2.0	-22.5
19.1		8.0	8.0	0	0
22.7		6.1	6.3		
26.6		4.6	5.0		
30.9		3.8	4.0		
35.4		3.2	3.2		
40.3		2.5	2.6		
45.5		2.0	2.1		
51.0		1.7	1.7		
56.8		1.4	1.4		
63.0		1.2	1.2		
69.4		1.0	1.0		

be perceived on density maps. Where the conditions are particularly favorable for living, as is often the case by rivers, along railway lines, etc., the demographic ridge-formation may be striking. The most obvious example of this is the circle arc of a town-spangled population ridge encircling Vaasa (Finland). This is mentioned to show that the density-topography can be useful in revealing and analyzing whole systems of central places.

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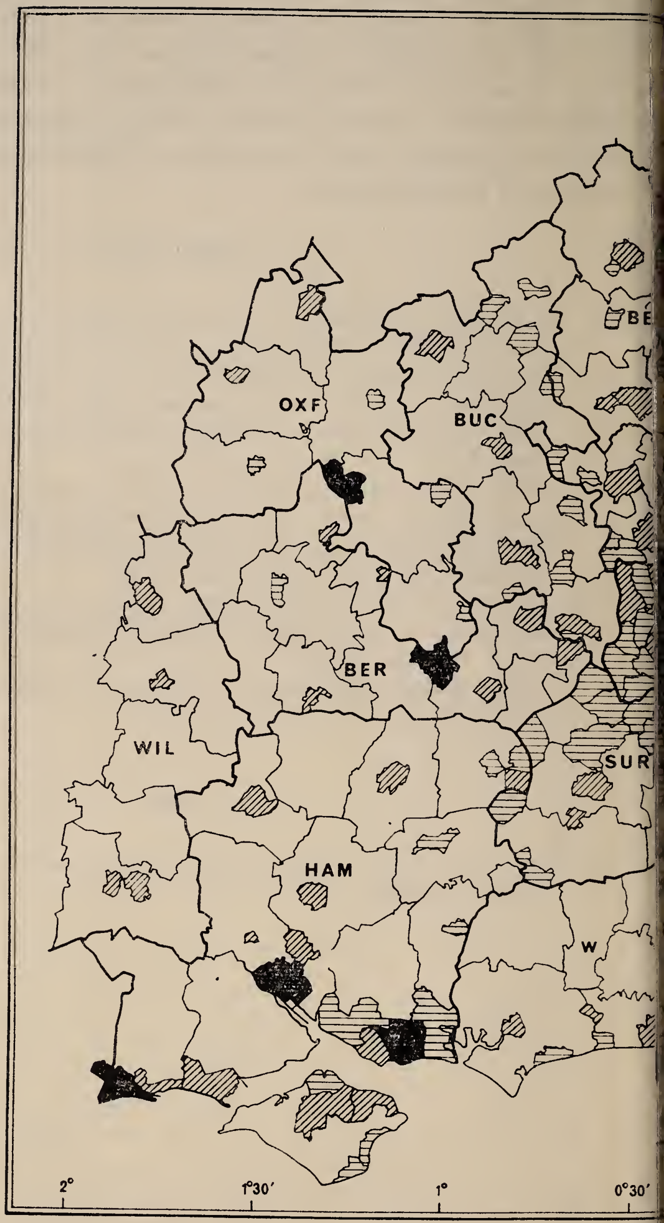
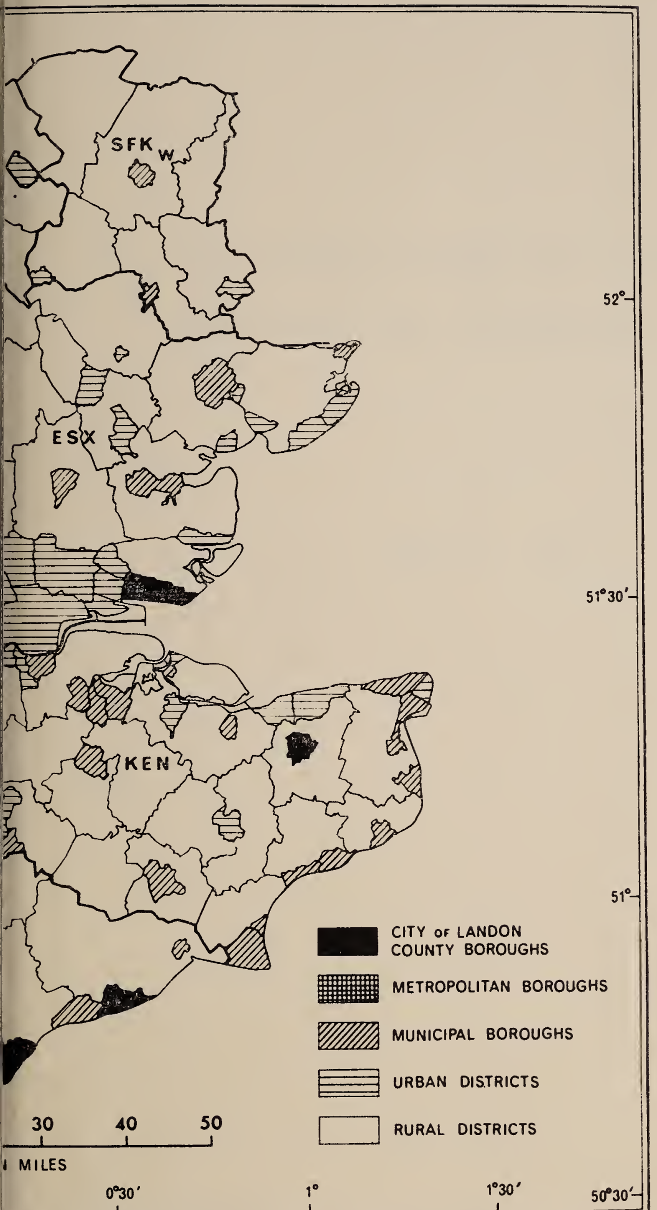


Figure 7. Map of administrati
Ordnance Surve



in the study. (Adapted from
Areas; Sheet 2).

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ON THE STRUCTURE OF POPULATION DENSITY IN LONDON'S FIELD

BY

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HELSINKI
1965

ON THE STRUCTURE OF POPULATION DENSITY IN LONDON'S FIELD

Density and density structure

Population density may be regarded as the most important variate in human geography. In setting a mass of people in relation to area, the concept of density makes possible a simultaneous scrutiny of two main elements of human geography, i.e. Man and his ecological base, which it joins into one quantity. As such, a density number, however, is nothing more than an element, although a combined one. The same reason which prevents the geographer from concentrating on an unconnected detail also prevents him from inferring very much from an isolated density number. Only when he is dealing with a set of densities which are in some way interconnected, do these form more than a mere lot of numbers. This 'more' is a rational structure which makes the set into something individual, with its own particular location and a form which has extent both in space and time. Moreover, it has, as is easy to imagine, its gradients, contour lines, partial derivatives, and so on. The set of density numbers thus formed can turn out to be a compact but analytically highly promising packet of data. How the numbers to be examined are to be collected is certainly of no little consequence. To be able to describe a subject, in this case London's field, the density numbers must be systematically associated with it. This might be accomplished e.g. by means of the equation

$$D = \sum_{0}^{r} P\,(r) \Big/ \sum_{0}^{r} A\,(r) \qquad (1)$$

where the numerator gives the population within the distance-range from naught to *r*, while the denominator gives the corresponding area. Consequently, D is the corresponding density.

Table 1. Densities at specified limiting distances. (Source, vide AJO 1964 B; Table 5).

Dist. mi	Density Pers/sq.mi. ('000)
1.4	14.5
2.5	40.6
3.9	41.0
6.3	32.1
8.6	22.9
11.2	19.3
14.2	14.8
17.6	10.9
19.1	8.0
22.7	6.1
26.6	4.6
30.9	3.8
35.4	3.2
40.3	2.5
45.5	2.0
51.0	1.7
56.8	1.4
63.0	1.2
69.4	1.0

Letting r take values from 0 to r, plotting (1) gives us a picture of the density distribution in London's field. The densities here dealt with, it should be mentioned, are not the usual local density-values, but densities averaged from the centre up, as far as that,[1] which means that the averaging is carried out with special regard to the centre. This brings out a systematic association with the centre.

The intensity and point of incidence of population density are socially of vital importance. Both belong so essentially together that they can be considered as forming the elements of density *structure.* Discrepancies in quantity and location, however, are not only indicative of differences in form. They also refer to functional differentiation. At the same time they reflect social differentiation. In view of density distribution one might, accordingly, speak about vertical resp. horizontal differentiation. The analysis of these is the subject matter of structural investigation. This paper has been written only to map out the main features of density structure.

[1] In the context, however it is simply termed density.

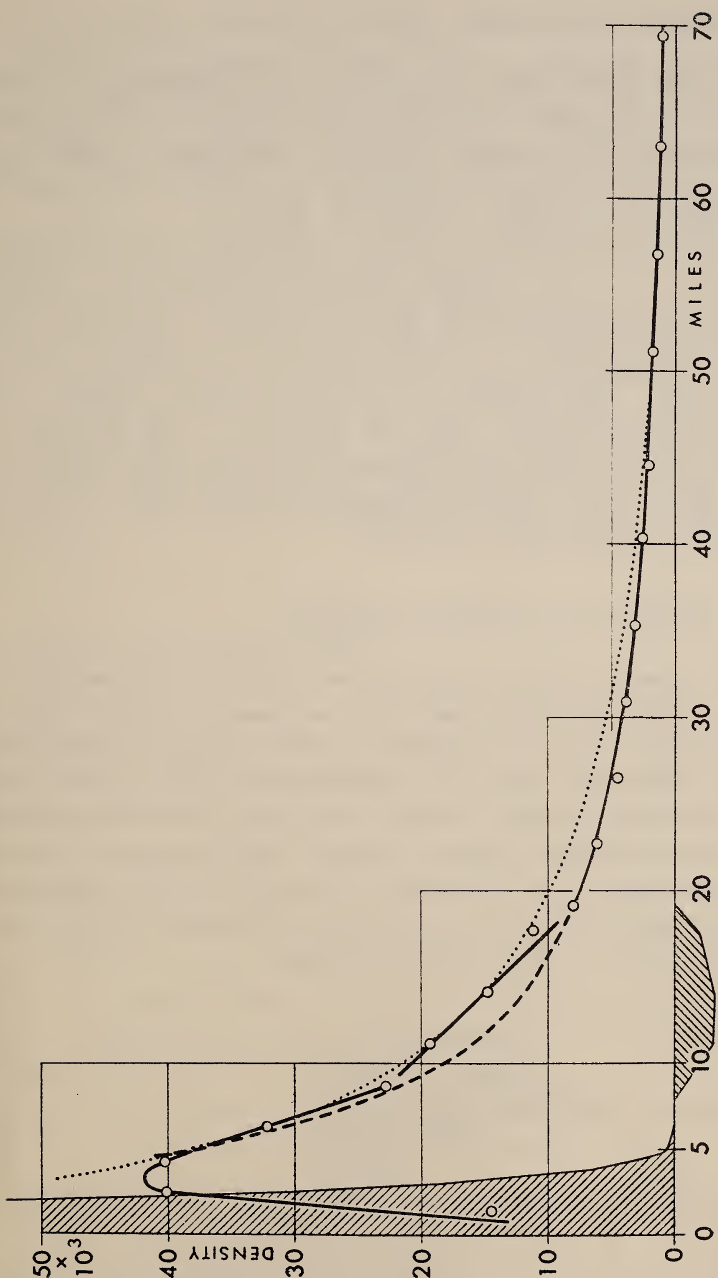

Figure 1. Density profile within London's field.

Observed density distribution

With a view to forming an idea of the main features of the density structure, a set of observational density-values was needed to stake-out approximately the progress of density distribution. Table 1 lists densities at specified limiting distances in London's field for 1961. The data given in this table is plotted in Figure 1.

The graphed density profile is seen to tail off at the outer edge of the field. In view of its relative length and conspicuous regularity this part of the graph manifestly forms the basis of the whole profile. This immediately invites one to extrapolate it backwards to produce the dashed line. With regard to its general progress relative to the observed values, this curve might be taken as a first approximation to an ideal curve, perhaps representing the driving field potential or stimulus. This we are going to compare with the actual or observed density values; see the graph in Figure 2.

Supposed mechanism of density formation

Figure 2 shows that the actual density follows the potential very closely from the outer field-end up to a distance of only five miles from the centre. Here it is hopelessly left behind as though forced to give up. From the curves one may infer that as long as the rate of change of the actual density matches that of the potential both change abreast with each other. But as soon as the former can no longer keep up the pace, it gets left behind. In one place the retardation of the one just compensates for the acceleration of the other. This happens at the maximum point of the actual density.

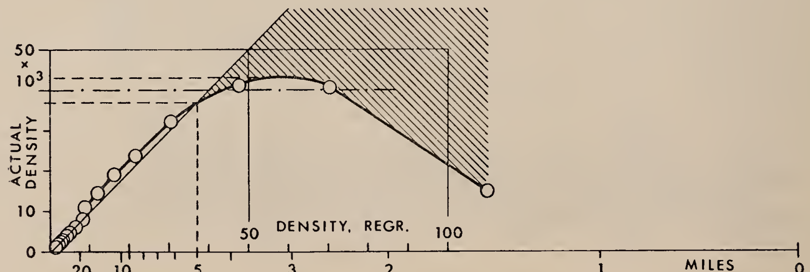

Figure 2. Comparison of actual and potential densities in London's field.

If this is found plausible, one may continue reasoning and assume, in analogy to the proposed driving force or stimulus, that there must be also a converse, that is, an impeding effect. This cannot possibly be anything else but a social hindrance. Perhaps it is the effect of prohibitive housing rents which accounts for the difference between the potential and actual densities, both of course, being expressed in the same dimension as that of density. The said difference is shown in Figure 1 as the shaded area, at the extreme left.

In exactly the same manner as costs exert an impeding effect, one may conclude that negative costs may be set equal to subventions, positive planning measures, etc. Technically one would identify them with a boosting effect to be added to the potential. True, there are also negative planning effects. Logically this would imply that in cases where the actual density differs significantly from the potential, this ought to be accounted for as positive or negative effects, as the case may be.

Considering the density profile

Figure 1 also shows that the highest density values occur, with one important exception, nearest to the centre. This is seen in the proximal steep slope of the density curve. It is of special consequence that there are, if any, either one or two distance values corresponding a given density, whereas there is always only one corresponding to a given distance. In other words: the density is a single-valued function of the central distance, but not vice-versa. This circumstance may also be referred to by saying that the density is distance controlled.

For this reason distance is given the foremost significance in the context. Especially, it is the best reference for designating and determining the social significance of a given location.

Accordingly, we may demarcate some characteristic distance ranges of density distribution. For instance, the following:

— Nearest to the centre there is the highly interesting inner zone. Next to it comes the outer central zone which ends well within the first ten miles from the centre.
— Adjacent to the former comes the intermediate zone about ten miles in width.

— At about twenty miles distance begins the rest, which slowly tails-off and might be labelled as the rural zone.

We are now going to consider these zones separately.

The rural zone

Let us begin with the rural zone. From the tentatively fitted two-parameter families, the square-root exponential was found to be affected by the smallest sum of residuals when describing the data. The curve

$$y_R = 69.4\ e^{-0.521 \sqrt{(x)}} \qquad (2)$$

gives an excellent fit. If the merits of this particular curve are estimated in the light of the chi-square test, we have $\chi^2 = 0.74$ which with 7 d.f. gives $P = 0.99$.

It is perhaps not a mere accident, that (2) belongs to the same family of curves which the writer found (1944, pp. 209 et 346 sqq) to represent the average (per person) net income within a given field. On account of the evident importance of this family in the field theory, the dependence described by it was designated as the field potential. It may well be, at least it is not out of question, that the income potential is the primary force of coherence in the present case as well, at the rural periphery of London's field. Anyway, the square-root-of-distance exponential is there. It is therefore possible that the actual density intimately follows the changes in the effective income potential. This correspondence, however, seems at first sight to be valid only within the rural conditions of density, i.e. below the apparently critical level of ten thousand persons per square mile. Above this level, the dependence takes on another form.

The central zones

The inner and outer central zones were mentioned above. They then came into focus by way of extrapolation from the rural periphery. This time, the opposite way is chosen, and the central zone given an autonomy which implies that the observed points included are taken as bench marks for curve fitting instead of considered as affected by systematical divergence from an extrapolated potential.

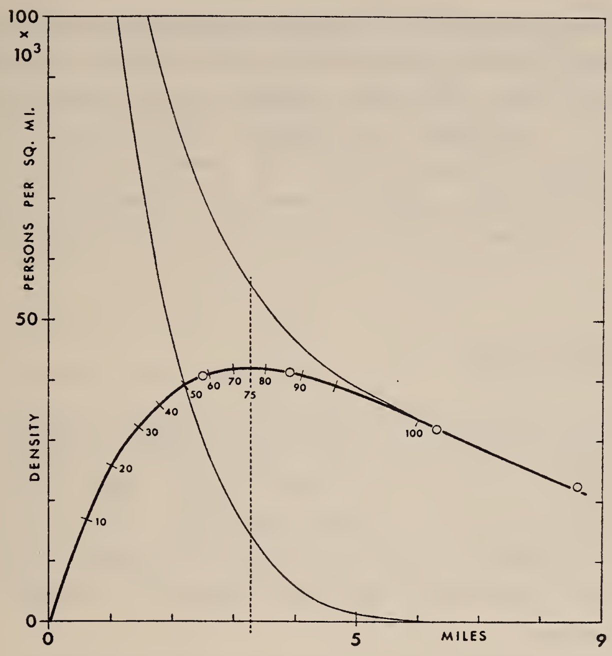

Figure 3. Regressed central zone density. For details, see text.

We are now trying to express the varying density directly in terms of central distance, that is as a function of it. It is found that the expression

$$y_C = 34.8\,x\,e^{-0.305\,x} \qquad x < 9 \qquad (3)$$

agrees closely with the observed points (cf. Figure 3). The expression describes, it must be said, the dependence of density on central distance very satisfactorily.

Considering this expression, it is seen that the density is herein proportionate to both x and $e^{-0.305\,x}$, which appear as factors in the right member of (3). The first one increases with the distance linearly and indicates centrifugal tendency, while the last one increases in the opposite direction exponentially and describes centripetal effort. Proportionate to both of these, the actual central zone density of (3) is shown in Figure 3 as the heavy line.

The fact that the equation thus built up gives values which agree closely with the observed points speaks in favour of its correctness.

Figure 3 also represents the assumed density potential. The difference between potential and actual is also shown. It reflects the density not absorbed. The scale marked on the actual density curve is there only to illustrate the variation in the absorbed density in terms of percent on the potential. No claim is, however, made that it holds good as such. On the contrary, it needs to be checked, as does the potential. We may perhaps get an opportunity to do this soon.

The intermediate zone

This zone coincides with the part of the graph which is a straight-line link between the central and rural zones. Actually, it forms a chord stretching through the higher density values on the concave side of the potential curve originally supposed. The divergence from the potential is shown as the shaded area. According to our working hypothesis, this apparently additional density is brought about by 'artificial' measures.

The density within this zone may be expressed as follows:

$$y_{\mathrm{I}} \doteq 35.0 — 1.4\ x \qquad 9 < x < 19 \qquad (4)$$

Recapitulation on density distribution

Having now dealt with density zones, a glance at Figure 1 makes it clear that a lengthwise subdivision along chosen density levels would have produced essentially the same result as the zoning by distance. Between levels 0 and 10, therefore, there is the density distribution characteristic of the rural part of the field.

The space between levels 10 and 20 carries the same points as the intermediate zone. And the still higher levels enclose essentially the same distribution we met with in the central zones. This means that there is an obvious dualism between both ways of grouping. Each denotes differentiation both socially and in regard to location. Yet it should be repeated that a density level does not suffice for a single-valued determination of location, whereas any central distance always corresponds to a given density. This was what was meant above by the term »distance controlled».

To substantiate this, let us compare Figure 1 with Figures 1 and 8 in a previous paper on London (AJO 1964 B). These show that the maximum population frequency in the group of metropolitan boroughs occurs at 3.3 miles distance from the centre. This coincides with the density maximum in Figure 1 of this paper. The joint frequency of the groups of county boroughs and metropolitan boroughs occurs at 8.8. miles. The fact that the first mentioned maximum falls within the inner central zone, and the last mentioned inside the outer zone, proves that the densities above level 20 correspond to the social mixture which characterizes the top level in the central place hierarchy.

The population of the central places' group labelled as urban districts is at maximum frequency at 14.2 miles' distance and between density levels 10 and 20, where it characterizes the intermediate zone.

All the remaining mass of population falls below density level 10 and beyond 20 miles distance, that is to say, in the rural zone consisting both of countryside in its various shadings and a number of scattered centra which come into categories other than metropolitan boroughs.

Survival of the fittest

Now we return again to Figure 1. It would be a grave mistake to conceive a density profile as a manometric reading of a simple variable. Even if the density is expressed in the form of a single measure, each reading is essentially the effect of many circumstances. Accordingly, a density profile throws light on much more than mere statistical population density. Its values are not just numbers. In view of their complicated nature, they are more like matrices.

The conclusion that each discussed zone has a distinct form of dependence of density on distance makes it evident that density values cannot reflect the thought-out potential in the extent of the field otherwise than *grosso modo* for instance in the form of an envelope common to all zonal subdistributions. This is shown in Figure 1 by the dotted line.

To make matters simpler, we represent all zonal distributions by straight lines, in Figure 4. Because the slope of all these lines is negative in the present system the actual zones in Figure 4 have come into being only insofar as they have succeeded in occupying the

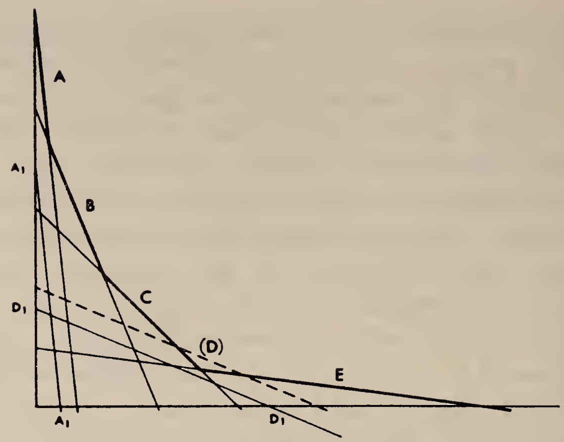

Figure 4. Simplified mechanism of zone-formation, Cf. text.

topmost position somewhere. In this system the interceptions as well as the slopes must be arranged into corresponding decreasing series. The graphs of A_1 and D_1 do not comply with this. Only when A has arisen to A_2, has it got its zone. D, too, will occupy its own zone, provided it can take up the position shown as a dashed line. It can be seen that the zone of greatest density is arranged nearest to the centre in this system. The others follow in their decreasing order.

The extensive land utilization taken up by agriculture cannot support a great density. In central places, however, it becomes possible, because the area covered by these yields more than it would in agriculture. The higher up the central place hierarchy we rise, the more we approach the centre. Moreover, both productivity and land rent follow suite. Distance is a strongly selective factor bringing the most central location within reach only of those who are most able to pay. The weaker are displaced, and only the strongest survive.

Central London

The census records show that the population of the City of London began a steady decline from 127,800 people, in 1851, to 26,900 in 1901 and 4,800 in 1961 (HALL 1964, p. 25). The actual City began this process in London. Holborn came second. Finsbury, Westminster and St. Marylebone came ten years later. The natural reason for this was that e.g. City merchants progressively made room for business

enlargement as the development of railways made it possible to commute from further afield (POLLINS 1964, p. 29). This movement out of the city centre produced a tremendous growth of suburban areas.

In the economic sector, the rapid development of commerce, industry, transportation, and communications brought about a strong rise in the standard of living. The new purchasing power thus injected was amplified by the multiplier effect familiar from economic theory, and was felt as an enormous increase in the demand for all sorts of services and immense areas of service space (e.g. for nourishment, recreation, entertainment, pleasure, offices, etc.).

Of these enterprises those which could pay most won and displaced the others. The resident population was struck hardest. It deserted the city for the suburbs. Consequently, a steadily increasing proportion of the employed are commuters. By 1962, 1,238,000 people were entering Central London on an average weekday morning (HALL, *ibid.*). In spite of the huge economic, psychic, social etc. costs of commuting, the momentum of this movement is still increasing. The number of jobs in Central London is growing (GLASS 1964, p. xv), and it has been figured that employment in Central London has been increasing at the rate of some 15,000 jobs a year (COPPOCK 1964, p. 102). In Figure 4 this developement means that line *A* is still rising, and as its zero-intercept goes up, rents in the centre increase, and so on: the process continues.

Day and Night population

People who have moved away from their jobs have, of course, sought their new dwelling places further afield, on a lower density level. This is a geographical fact. In the first place, however, it is a social phenomenon. At the same time the division of labour and the creation of new jobs have produced an unforeseen fragmentation of crafts and professions, the same development has forced the people to apportion their time for different purposes. Thus the individual is also made a victim of atomization!

Day and night populations are the product of the said evolution. In parts of Central London the occupying day population is already five times as great as the occupying night population (*cf.* WESTERGAARD 1964 p. 100).

In order to evaluate daytime densities, the day population is determined as the sum of the known night population and an estimated proportion of the arriving total of commuters. Thus we obtain a density of 99.4 at 2.5 miles, and 42.9 at 3.9 miles distance limit.

Dormitories

The struggle for Inner London's best and most representative space, once set going by the impulsive evolution of traffic and technology, has in an ever increasing measure displaced the former resident population. Inner London's daily activity, put to a more productive use, depends on enormous numbers of persons living elsewhere, now mostly in suburban dormitories outside the County of London.

By 1951, the Central boroughs were drawing half their day-time labour force from outside the County of London (WESTERGAARD, *o.c.* 106). At the moment, the population size of London County is steadily declining, both through voluntary and planned dispersal (GLASS, *o.c.* xv), while the number of jobs in Central London is still growing.

Consequently, the number of commuters who work in the centre is growing rapidly. As it grows, the geographic specialization of free-time occupancy or dormitory areas is becoming more pronounced.

In the light of these facts, one could be tempted to interpret the relatively high density values of the intermediate zone, shown in Figure 1, as an effect of the planned and subsidized dispersal so commonly considered characterisic of a dormitory area. All this is, however, only an illusion. Neither is the dependence of density on distance unique or general, and this is why we cannot extrapolate the rural dependence into other zones where zonal densities obey their own laws, as we have shown in the section »Survival of the fittest».

In spite of the zonally individual features, there is evidently also a general tendency in the dependence of density on distance. It is this general tendency which governs the system as a whole. Our hypothesis is that the said dependence forms an envelope to the zonal subdensities. As such it not only governs but also describes the system. The dotted line in Figure 1 is a case in point. As a square-root exponential it may remind us of the distribution of

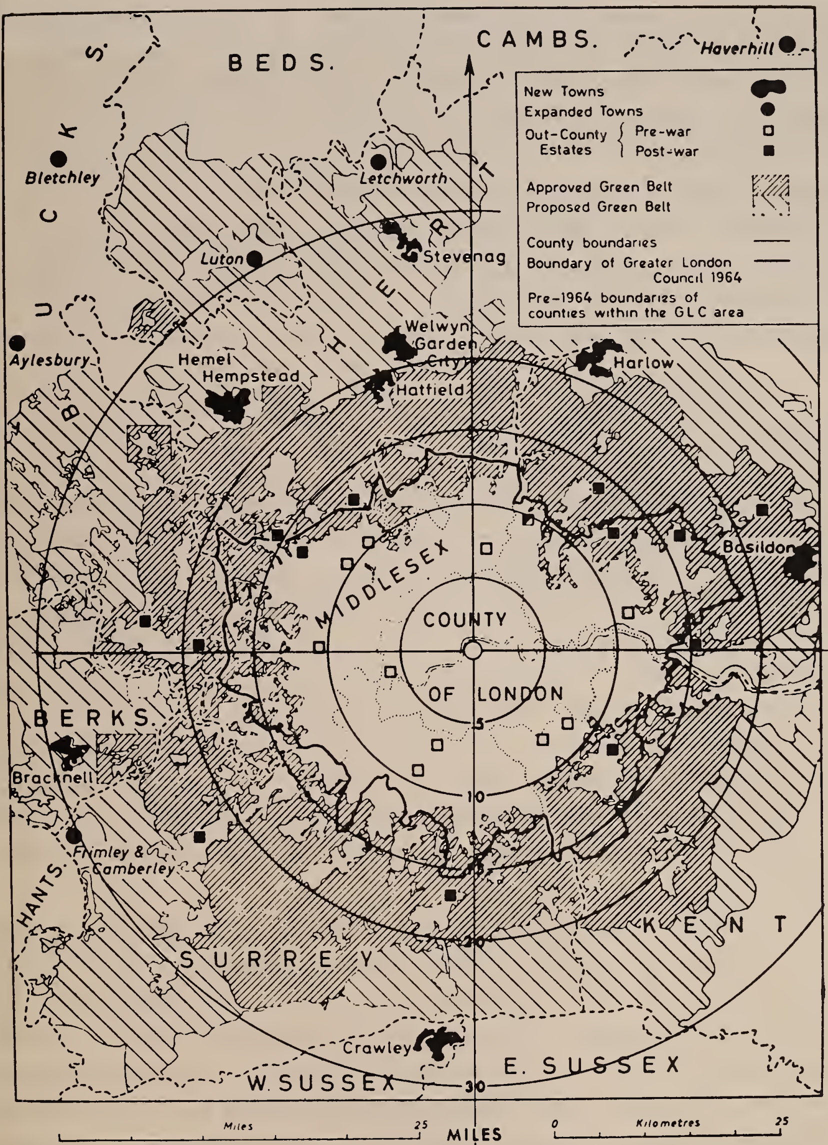

Figure 5. Green Belts and New Towns around London. (Source: Adapted from M. J. Wise, o.c. p. 20).

income on an average net per capita basis. In Finnish conditions this would in fact be the case (AJO 1944, pp. 289 resp. 346 sqq), but that is no reason why it should be transferable into English geography. Nevertheless, it is common sense to argue that there must be an income gradient irrespective of its mathematical form, as an active stimulus without which the central attraction could not last.

Another point of interest with regard to dormitories is the Green Belt and the new towns beyond it. Both are shown in Figure 5. A comparison of this with Figure 1 makes everything seem to fall in place in the system depicted without any noticeable disturbances.

Summary

The declining size of Central London's population has become proverbial. One might have expected that the most focal point of human contacts in a mammoth metropolis would coincide with the summit of concentration of residents. On the contrary, masses of people are moving away to make room for offices and other enterprises closely dependent on highly central location and able to pay its costs. Then, of course, there are the status-giving head-quarters of big firms, top-class hotels, entertainment etc. This kind of areal refill means that there is nothing to relate about the densities of resident population. The employed day-time population is already five times that much. We must add, too, the masses of sought-for clientèle, other visitors, passers-by etc.

No wonder, therefore, that it has hitherto been taken for granted that the gradients which in other urban regions culminate in the centre, cannot do that in London, because »it is different». The author had no prejudices. The progressive desertion of Central London's homes is, however, growing worse under the steadily increasing pressure. May it not, then, be a kind of gradient culminating in the very centre.

We now realize that there is only one governing stimulus: the general potential. All individual subgroups become arranged according to their regional system in an outward-moving decreasing gamut of gradients. It is an ecological fight for the survival of the fittest, as it is everywhere. The density structure of a metropolitan field makes no exception from general principles.

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EIN UNGARISCHES DORF (NEMESVÁMOS) IM SÜD-BAKONY

SIEDLUNGSGEOGRAPHISCHE STUDIE

von

KALEVI RIKKINEN

HELSINKI
1965

INHALTSVERZEICHNIS

EINLEITUNG

Im Sommer 1963 hielt ich mich dank einem Stipendium vom Finnisch-Ungarischen Kulturkomitee drei Monate in Ungarn auf. Während eines beträchtlichen Teiles der Zeit machte ich mich mit den Gebieten des Balatonsees und des Bakonywaldes vertraut. Hier wandte sich meine Aufmerksamkeit in erster Linie dem Dorfe Nemesvámos zu, das ich viele Male aufsuchte. Als es mir dann gelang, vom Gemeindehaus des Dorfes auf kurze Zeit eine im grossen Massstab gezeichnete, genaue Karte (1: 2 280) vom Jahre 1923 zur Verfügung zu erhalten, begann ich Aufbau und Entwicklung des Dorfes zu untersuchen. Die Klarlegung seines gegenwärtigen Gefüges gründet sich einzig auf Feldbeobachtungen. In Dankbarkeit gedenke ich der Dorfbewohner, von denen viele bereitwillig ihre Hilfe dabei anboten.

Der Flächenraum der Gemeinde Nemesvámos fasst 4 079 ha. Ihre Besiedlung beschränkt sich beinahe völlig auf ein einziges Dorf. Streusiedlung kommt im Gebiet der Gemeinde, wie in Ungarn überhaupt, nur wenig vor. Die gesamte Einwohnerzahl der Gemeinde belief sich im Jahre 1960 auf 1 627, davon entfielen auf das zur Untersuchung vorgenommene Dorf Nemesvámos 1 543 Bewohner (KSH 1963).

Zweck der Untersuchung ist es, die Struktur der Besiedlung des Dorfes Nemesvámos zu erforschen sowie den Einfluss von Naturverhältnissen, historischen und wirtschaftlichen Umständen auf ihre Entwicklung nachzuweisen zu versuchen.

Ich danke Dr. phil. Marta Römer, die die Übertragung der Arbeit ins Deutsche besorgt hat.

Kalevi Rikkinen

LAGE UND NATURVERHÄLTNISSE

Nemesvámos liegt im südlichen Teil des Bakonywaldes (Abb. 1). Diese umfassendste Gebirgsgegend Ungarns besteht grösstenteils aus mesozoischem Kalkstein oder Dolomit. Die nordost-südwestlich gerichteten Hauptverwerfungen zerstückeln den Bakonywald in viele verschieden hohe (200—700 m) Schollen. Die wichtigste Verwerfung (Székesfehérvár-Veszprém-Devecser) zerlegt das Gebirge in den Nord- und den Süd-Bakony. Sowohl die Landstrasse als auch die Eisenbahn gehen dieser Linie nach, die siedlungsmässig und wirtschaftlich den wichtigsten Raum des Bakony darstellt. Von dieser Hauptbruchlinie zweigt sich bei der Stadt Veszprém eine kleinere, parallel zum Balaton verlaufende Einsenkungslinie ab, die sich bis zum Tapolca-Becken im Südwesten fortsetzt. Zugleich bildet sie die Grenze zwischen dem Süd-Bakony und dem Balaton-Oberland (Pécsi & Sárfalvi 1962, S. 152). Das als Untersuchungsgegenstand vorgenommene Dorf Nemesvámos liegt am Südrande dieses kleineren Grabenbruches in etwa 7 km Entfernung von Veszprém.

Trotz der angemessenen Niederschlagsmenge (700—800 mm/J.) herrscht im Gebiet des Bakony Wassermangel. Bachtäler kommen reichlich vor, aber sie sind einen grossen Teil des Jahres ausgetrocknet. Das Regenwasser verschwindet schnell von der Erdoberfläche als Karstwasser in den Kalkfelsgrund. Das Aufkommen ständiger Besiedlung ist dadurch nur da, wo andauernde Wasserzufuhr verbürgt ist, möglich gewesen. Im Bakony-Raum erscheint denn auch in den Namen der Siedlungszentren allgemein das Wörtchen *kút,* das Brunnen bedeutet. Meist liegen die Dörfer in den Randteilen der Verwerfungslinien, wo das Karstwasser am häufigsten in Quellen zutage tritt. Die dörferverbindenden Hauptstrassen verlaufen in Einbruchtälern, die oft auch die fruchtbarsten Agrargebiete sind.

Eine nähere Betrachtung der Naturverhältnisse von Nemesvámos lässt erkennen, dass auch seine Lage eng mit der Wasserfrage zusammen-

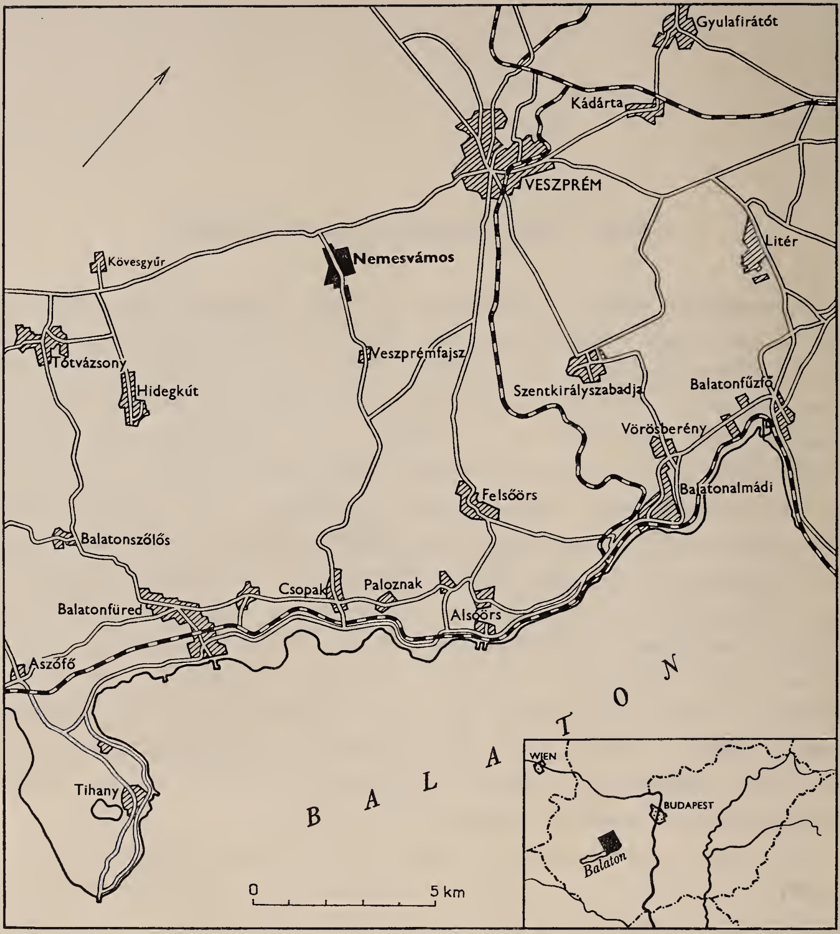

Abb. 1. Lage von Nemesvámos.

hängt. Die Dorfmitte liegt in rd. 700 m Entfernung von der dem trockenen Einbruchtal folgenden Landstrasse Veszprém-Tapolca (Abb. 2). Die Besiedlung hat sich in einem kleinen Quertal gesammelt, wo die Wasserzufuhr infolge des geologischen Aufbaus besser als im Hauptal ist. In einem mit der durch das Dorf verlaufenden Strasse gleichgerichteten Profil lässt sich eines der im ganzen Balaton-Oberland angetroffenen vollständigsten Profile der mittleren und oberen Trias feststellen (Laczkó 1911, S. 92). Oberhalb des Dorfes, in mergelhaltigem Gebiet, liegen drei Quellen: Nagykút, Kiskút und Ányos-kút

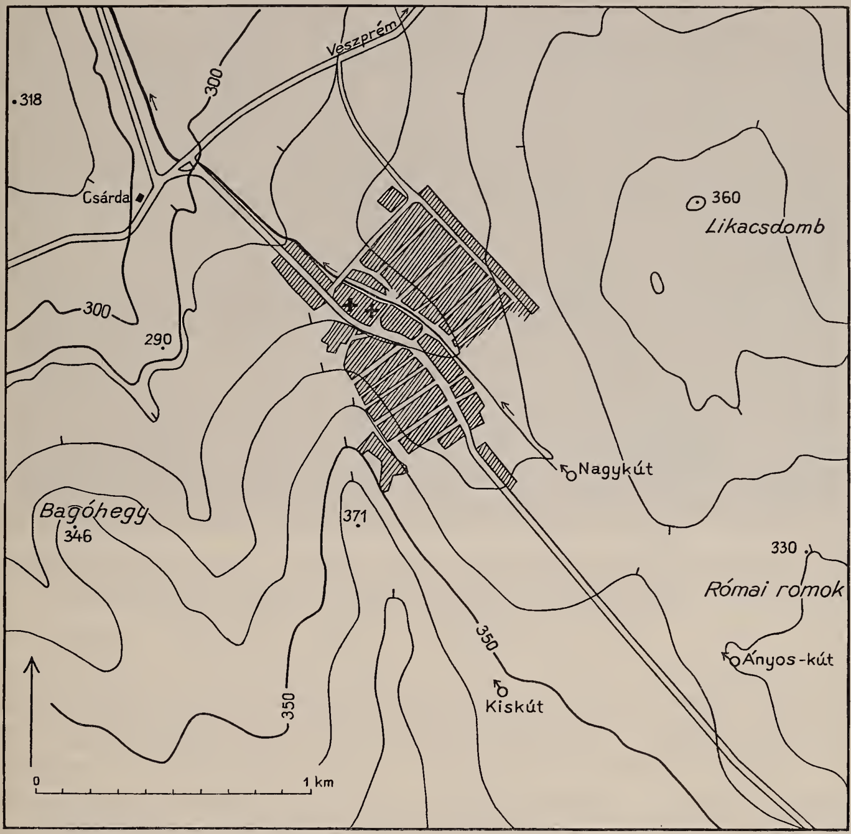

Abb. 2. Höhenverhältnisse und Nahumgebung von Nemesvámos.

(Abb. 2), die auch den durch das Dorf fliessenden Bach (Séd patak) mit Wasser versorgen. In trockener Zeit schwindet jedoch der Bach, sobald unterhalb des Dorfes der mergelhaltige Felsgrund in Dolomit übergeht (op.c., S. 43). Dies erklärt auch das Vorhandensein von Brunnen im Dorfgebiet, ja sogar auch auf dem oberen Talhang. Dagegen ist in den schon alten Gasthof (Csárda), der etwas abseits vom Dorfe an der Hauptlandstrasse liegt (Abb. 2), das Wasser aus dem Dorfe zu holen.

Auch sind die Bodenverhältnisse besonders in den mittleren Teilen des Dorfes für den Landbau gut geeignet. Das Tal ist ein asymmetrisches Erosionstal tektonischen Ursprungs. Die Scheitel der an

Abb. 3. Das Dorf Nemesvámos von Südwesten gesehen. Es liegt in einem Erosionstal tektonischen Ursprungs, das sich mit fruchtbaren losen Bodenarten angefüllt hat. In der Umgebung herrschen trockene Wiesenflächen vor.

den Rändern des Tales ansteigenden Hügel sind entweder nackte, trockene Dolomitflächen oder kiesgründige Wiesengelände (Abb. 3). Je weiter man die Hänge abwärts steigt, um so beträchtlicher vermindert sich der Anteil des groben Materials und um so stärker vermehrt sich entsprechend die Menge der feineren Komponenten und der Feuchtigkeit. Auf den Talhängen sind niedrige Stufen zu erkennen. Bei der im Gebiet unter der Führung von Dr. Márton Pécsi im Sommer vorgenommenen geomorphologischen Kartierung, die Verfasser teilnehmen konnte, ergab sich, dass der Aufbau unter periglazialen Verhältnissen entstanden ist und die fruchtbaren unteren Talteile als sog. Gehängelöss anzusehen sind.

HISTORISCHER HINTERGRUND DER BESIEDLUNG

Obgleich die Naturbedingungen die allgemeinen Voraussetzungen der Lage von Nemesvámos bestimmen, ist ihr Einfluss als siedlungssteuernder Faktor nicht immer gleicherweise hervorgetreten. In Betracht zu ziehen sind Schwankungen in den Wirtschaftsformen sowie die

Menge der Bevölkerung und ihre soziale Stellung. Diese Faktoren hängen ihrerseits eng mit der allgemeinen historischen Entwicklung zusammen.

Eine ständige Besiedlung kam im Gebiet von Nemesvámos schon in römischer Zeit auf. Die Provinz Pannonien reichte im Osten bis zur Donau. An ihrer Romanisierung beteiligten sich neben den an den Grenzen bestehenden Truppenlagern in beträchtlichem Masse auch die nördlich des Balaton entstandenen römischen Siedlungszentren. Aus Italien übergesiedelte Grossgrundbesitzer liessen sich schon im ersten Jahrhundert in diesem waldreichen Gebiet nieder (Thomas & Szentléleky 1959, S. 21—23). Durch reichliche Funde hat erschlossen werden können, wie die Römer hier zur Zeit ihrer vierhundertjährigen Herrschaft gelebt haben. Der bedeutendste Siedlungsfund ist gerade im Gebiet von Nemesvámos gemacht worden. Dieses sog. Balácapuszta liegt rd. 800 Meter vom Rande des heutigen Dorfes nach Südosten, also in dem weiter oben genannten Quellengelände (Abb. 2). Balácapuszta bildete einst einen überragenden Mittelpunkt, Reste seiner Bauwerke nebst Mosaikböden gelten als die prächtigsten Funde Pannoniens (op.c., S. 23). Durch Balácapuszta verlief auch die einzige wichtige Landstrasse des Balaton-Oberlandes. Sie führte nach Óbuda oder also dem gegenwärtigen Budapest (Rhé 1906, S. 28).

Balácapuszta vertrat eine für die damalige Zeit typische *Villa*-Siedlung. Es umfasste nur ein einziges Landgut, zu dem ein Palast sowie einige Wohn- und Wirtschaftsbauten gehörten. Die Landwirtschaft wurde mit Sklavenarbeitskraft betrieben, und die damals noch reichlich vorhandenen Wälder wurden verschwenderisch genutzt. Dass Balácapuszta seine Lage bei einer Quelle an einer wichtigen Handelsstrasse erhielt, ist leicht zu verstehen. Die Quelle bildete eine »Oase», obschon sie höher und dadurch mit ihrer Umgebung auf trockenerer Fläche gelegen war als beispielsweise die mittleren Teile des heutigen Dorfes im Tal.

In den Zeiten der Völkerwanderungen zogen sich die Römer aus Pannonien zurück. Vor der Einwanderung der Ungarn (Ende des 9. Jahrhunderts) war das Land den Angriffen vieler Nomadenstämme ausgesetzt. Nachdem die Ungarn einen Staat gebildet hatten und vom Nomadentum zum Ackerbau übergegangen waren, ist die Entwicklung

von Nemesvámos eng mit dem Leben der Stadt Veszprém verknüpft gewesen. Diese in unmittelbarer Nähe von Nemesvámos entstandene Stadt entfaltete sich schon früh zu dem bedeutsamsten Kultur-, Verkehrs- und Handelszentrum des Bakony. In Veszprém wurde schon im Jahre 1009 ein Bischofsstuhl gegründet, und es wurde der Wohnsitz der Königin von Ungarn (Békefi 1907, S. 4—5). Im 13. Jahrhundert gründete man in der Stadt die erste Hochschule Ungarns. In Veszprém wohnten Adelige, die den in den Dörfern wohnenden Bauern Steuern auferlegten.

Der Name des Dorfes Nemesvámos erscheint zum erstenmal in Urkunden in den Formen *Kyswamos, Kisvámos* sowie *Naghwamos, Nagyvámos* (Laczkó & Rhé 1912, S. 12—13; Illésfalvi 1954). Dies weist darauf hin, dass sich die Besiedlung anfangs an zwei Orten gehäuft hat. Auf Grund der Namen kann geschlossen werden, dass sie an zwei rd. 800 m voneinander entfernten Quellen (Kiskút, Nagykút) gelegen haben. Die Besiedlung um die Quelle Nagykút ist also ziemlich nahe dem Rande der jetzigen Dorfsiedlung aufgetreten. Die Komponente *vámos* (vám = Zoll; vámos = Zollwächter) in den Namen der Dörfer weist auf die in ihnen geleisteten Zahlungen hin. Aus dem Jahre 1233 hat sich auch ein urkundlicher Beleg für die an den Adel entrichteten Steuern erhalten (Illésfalvi 1954). In das ausgehende 14. Jahrhundert reicht ein Zeugnis darüber zurück, dass das Nonnenkloster von Veszprém Grundbesitz in Vámos hatte (Békefi 1907, S. 64).

Über Umfang und Aufbau der Besiedlung von Kisvámos und Nagyvámos haben sich keine Angaben beibringen lassen. Verglichen mit der Lage von Balácapuszta kann jedoch gesagt werden, dass die Besiedlung nun durchschnittlich weiter abwärts im Tal gelegen hat. In dieser Gegend erstrecken sich auch gegenwärtig die besten Äcker. Die verhältnismässig grosse Bedeutung der Dörfer gegenüber denen des umliegenden Gebietes wird dadurch erwiesen, dass sie zum mindesten schon im 16. Jahrhundert eine Kirche hatten. Dies kann daraus geschlossen werden, dass in kirchlichen Urkunden aus dem Jahre 1539 von einem Pfarrer von Vámos die Rede ist (Békefi 1907, S. 92). Nach der angewandten Benennung zu schliessen, sind die Dörfer vermutlich schon damals miteinander verschmolzen gewesen, wodurch sie, bei der drohenden Türkengefahr, leichter zu verteidigen gewesen sind.

Nachdem die Türken 1526 in der Schlacht bei Mohács einen Sieg über die Ungarn erfochten hatten, besetzten sie 1541 Buda. Später erweiterten sie ihren Machtbereich im Westen bis Veszprém.

Der grösste Teil des Landes wurde dadurch von den Türken besetzt, auf etwa 150 Jahre. Bei Annäherung der Türken nahmen die Bewohner von Vámos ihre Zuflucht zu der im 15. Jahrhundert erbauten Feste von Veszprém. Doch hatte sich die Stadt 1552 zu ergeben (Békefi 1907, S. 13). Zur Zeit der Belagerung durch die Türken wurde die Siedlung Vámos völlig vernichtet (Illésfalvi 1954).

Im späten 17. Jahrhundert zogen sich die Türken endgültig aus Ungarn zurück. Doch befreiten sich die westlichen Teile des Landes schon früher, so konnte die nach Veszprém geflohene Bevölkerung schon nach 1610 auf das Land zurückkehren. Während der Türkenzeit wurde die Einwohnerzahl unglaublich gering. Im Gebiet des Bakony reichte die Bevölkerung nur noch für einen Teil der früheren Dörfer aus (Pécsi & Sárfalvi 1962, Karten S. 241—242). Es ist festgestellt worden, dass im Namenverzeichnis der Bewohner des Dorfes Vámos schon im Jahre 1458 etwa 20 der heutigen Familiennamen vorgekommen sind (Csánki 1890—1897, Bd. II, S. 258). Nach Vámos sind also viele Nachkommen der schon vor der Türkenzeit im Dorfe Ansässigen zu neuer Niederlassung zurückgekehrt.

Nach der Türkenzeit entwickelte sich das Dorf an seiner heutigen Stelle. In bezug auf die Römersiedlung Balácapuszta verschob sich der Schwerpunkt der Siedlung also aus dem Bereich der Quelle auf die Talsohle. Die unteren Teile des Tales sind landwirtschaftlich fruchtbar, aber dies allein reicht nicht aus, zu erklären, warum sich der Schwerpunkt der Siedlung verschoben hat. Einer der wichtigsten Gründe dürfte darin bestehen, dass man dadurch der Stadt Veszprém, in deren unmittelbaren Einflussbereich das Dorf immer mehr geriet, näher rückte. Zugleich ist eine Entwicklung zu einer dichteren Siedlungsform zu erkennen. Während das *Villa*-Gut eine Art Einzelsiedlung und Kisvámos und Nagyvámos zwei gesonderte kleine Dörfer darstellten, entwickelte sich nun im Tale eine einzige dichte Dorfgemeinschaft. Diese Entwicklung ist grossenteils dem Durchbruch des Ackerbaus sowie Verteidigunsgesichtspunkten zu verdanken. Diese feste Bauart von Nemesvámos ist ausserdem dadurch, dass die Bauern dem Adel Steuern zu zahlen hatten, wesentlich bewirkt worden. Darauf wird weiter unten (S. 22) ausführlicher einzugehen sein.

ALLGEMEINE ENTWICKLUNG VON BEVÖLKERUNG UND ERWERBSGEFÜGE

In Ungarn war das ganze 18. Jahrhundert eine starke Siedlungszeit. So stieg z.B. im Komitat Veszprém (Veszprém vármegye) die Menge der Steuerzahler vom Jahre 1720, als sie sich auf 35 999 belief, bis zum Jahre 1787 auf das Dreifache (MSK 1896, S. 66). Damals wanderten in das Gebiet auch viele Deutsche (Schwaben) ein. Doch erhielt sich Nemesvámos als ein beinahe rein ungarisches Dorf. Im Jahre 1900 gab es unter den Dorfbewohnern nur 26 solche, deren Muttersprache nicht Ungarisch war (MSK 1902).

Die ersten Angaben von Einwohnerzahlen nach Gemeinden stammen aus den Jahren 1715—1720, als in Ungarn staatliche Steuerverzeichnisse aufgestellt wurden. Die Verzeichnisse enthalten die Personalien der dem Staate Steuern zahlenden Bevölkerung. Nach dem Verzeichnis gab es in Vámos 1715 nur 13 steuerzahlende Haushalte, von denen 5 Kleinbauern und 8 der Steuerarbeit unterstehende Bauern waren (MSK 1896). Doch entsprechen die Zahlen bei Vámos gar nicht der richtigen Einwohnerzahl des Dorfes. Die Mehrzahl der Bauern zahlte nämlich Steuer nur an die in Veszprém wohnenden Adeligen. Im Verzeichnis von 1720 stand kein einziger Staatssteuerzahler mehr. Vámos stand damals steuermässig ganz im Besitz des Adels, d.h. es war sog. *curialis* (»adeliger Besitz»).[1] Aus demselben Verzeichnis geht auch hervor, dass das Dorf ein reines Landwirtschaftsdorf war, es gab dort keinerlei Industrie (op.c., S. 162).

Die Statistiken berichten, dass die Einwohnerzahl des Dorfes schon im 18. Jahrhundert annähernd ihren heutigen Stand erreicht hat. Die Entwicklung der Einwohnerzahl von Nemesvámos geht aus der folgenden Zusammenstellung hervor (Illésfalvi 1954; KSH 1962).

1786	1 302	1920	1 480
1869	1 566	1930	1 554
1880	1 609	1941	1 571
1890	1 559	1949	1 529
1900	1 435	1960	1 627
1910	1 479		

[1] Das Dorf hiess amtlich Vámos bis zum Jahre 1909, als sein Name Nemesvámos (nemes = adelig) wurde. Schon 1786 wurde es zuweilen »Nemes Falu» genannt (MSK 1912; Illésfalvi 1954).

Die Zahlen bedeuten die gesamte Einwohnerzahl der Gemeinde. Sie umfassen also ausser dem zu untersuchenden Dorf auch die übrigen im Gebiet der betreffenden Gemeinde ansässigen Bewohner. Deren sind es jedoch nicht sehr viele. Im Jahre 1960 z.B. lebten in der Gemeinde Nemesvámos ausserhalb des Hauptdorfes nur 74 Bewohner, die meisten von ihnen in Vilmapuszta, nahe der Grenze der Stadt Veszprém. Csárda, Csomaitanya und Molnártanya umfassen nur ein Gehöft (KSH 1962). Da der Flächenraum der Gemeinde beinahe unverändert geblieben ist (1900 6 999 Katastraljoch [1], 1960 7 088 Katastraljoch = ca. 4 079 ha), können die dargestellten Einwohnerzahlenangaben als vergleichbar angesehen werden.

Um die allgemeine Bevölkerungsentwicklung von Nemesvámos zu verstehen, ist sie mit den übrigen Gemeinden der Gebiete von Balaton und Bakony zu vergleichen. Das beigegebene Diagramm (Abb. 4) zeigt ausser der Entwicklung der Einwohnerzahl von Nemesvámos auch die der Einwohnerzahlen aller bis in 10 km Entfernung davon gelegenen Landgemeinden und der Stadt Veszprém. Im Diagramm unterscheiden sich deutlich als eigener Typ die steil aufsteigenden Kurven von Veszprém (1), Balatonfüred (2) und Balatonalmádi (3). Von diesen ist Veszprém ein altes Kultur- und Industriezentrum des Binnenlandes, die übrigen wiederum schnell entwickelte Badeorte und Touristenziele. Ufergemeinden am Balaton sind ferner Vörösberény (9) und Csopak (10), die auch nach 1920 verhältnismässig schnell gewachsen sind. Aus den der Logarithmenskala zugeordneten Kurven ist unmittelbar zu ersehen, dass die Gemeinden mit hoher Einwohnerzahl sowohl absolut als auch relativ schneller als die kleinen angewachsen sind. Die Gemeinden sind grösstenteils solche, in deren Einwohnerzahlen im Verlaufe von hundert Jahren nur geringe Veränderungen eingetreten sind. Bei den meisten Gemeinden ist eine auf den Zweiten Weltkrieg zurückzuführende Verminderung der Volksmenge zu erkennen.

Bei Vergleich der Einwohnerzahl mit der Entwicklung der erwerbsmässigen Verteilung der Bevölkerung nach dem Zweiten Weltkrieg kann die allgemeine Erscheinung festgestellt werden, dass, je überwiegender die Gemeinde landwirtschaftlich gewesen ist, ihre Bevölkerung um so weniger zugenommen hat (Abb. 4; vgl. auch KSH 1963, Beilagekarten). In einigen Nemesvámos benachbarten Gemeinden mit vorherrschender

[1] 1 Katastraljoch (ung. katsztrális hold) = 0,5754 ha.

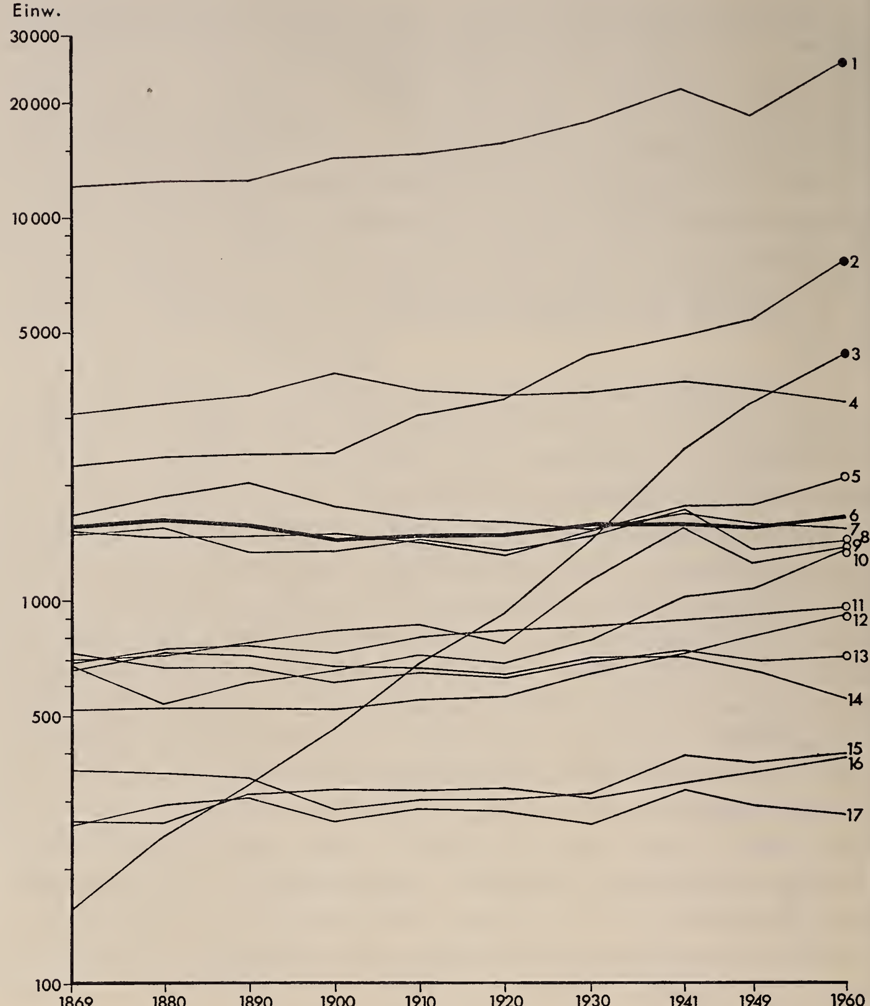

Abb. 4. Die Entwicklung der Einwohnerzahl des Dorfes Nemesvámos und der ihm nahe gelegenen Gemeinden von 1869—1960 (KSH 1962).

———● = Agrarbevölkerung 1960 unter 20 %
———○ = Agrarbevölkerung 1960 20—40 %
——— = Agrarbevölkerung 1960 über 40%

Namenverzeichnis der Gemeinden (vgl. Abb. 1) 1. Veszprém, 2. Balatonfüred, 3. Balatonalmádi, 4. Szentgál, 5. Gyulafirátót, 6. NEMESVÁMOS, 7. Tótvázsony, 8. Szentkirályszabadja, 9. Vörösberény, 10. Csopak, 11. Felsőörs, 12. Alsóörs, 13. Kádárta, 14. Hidegkút, 15. Lovas, 16. Paloznak, 17. Veszprémfajsz.

Landwirtschaft verringerte sich die Einwohnerzahl durch grosse Umzugsbewegung 1949—1959 sogar um über 20 %.

Nemesvámos war bis zum Zweiten Weltkrieg eine reine Agrargemeinde, und in jener Zeit blieb seine Einwohnerzahl beinahe unverändert. Die um die Jahrhundertwende eingetretene geringe Verminderung der Einwohnerzahl ist durch Auswanderung nach Amerika bedingt gewesen (MSK 1912), während die Kriegszeit das Abnehmen bis zum Jahre 1949 erklärt. Nach dem Kriege begann der relative Anteil der ihren Unterhalt aus der Landwirtschaft Beziehenden sich zu vermindern, obgleich sich in der Gemeinde keine Arbeitsplätze für Betreiber städtischer Gewerbe herausbildeten. Dagegen ging man in stets wachsender Menge dazu über, auf Arbeit ausserhalb der Gemeinde zu gehen, hauptsächlich in Veszprém, das sich nach dem Kriege schnell entwickelte. An aus der Landwirtschaft freiwerdender überzähliger Bevölkerung verzogen allerdings aus der Gemeinde auch 116 Personen in den Jahren von 1949—1959. Dank natürlicher Bevölkerungszunahme blieben als wirklicher Volkszuwachs in demselben Zeitraum jedoch 98 Personen (KSH 1962). Bedeutsam ist also, dass ein beträchtlicher Teil der Bevölkerung allmählich aus der Landwirtschaft in den Dienst städtischer Gewerbe übertrat, aber doch an seinen früheren Wohnplätzen blieb. Im Jahre 1960 gab es schon rd. 300 Pendler.

Neben den Wandlungen im Gewerbegefüge der Bevölkerung ging im Verlaufe des letzten Jahrzehnts eine Umstellung zum sozialistischen Wirtschaftssystem einher. Doch wurden erst im Jahre 1958 alle Ländereien verstaatlicht.

DIE BESIEDLUNG IM JAHRE 1923

Die oben beschriebenen Veränderungen in Erwerbsstruktur und Wirtschaftssystem der Bevölkerung spiegeln sich mit der Zeit natürlich auch in der Besiedlung. Zum Verständnis der vor sich gegangenen Entwicklung wird im folgenden zunächst die Verteilung der Besiedlung von 1923 in erster Linie auf Grund der vom Gemeindehaus von Nemesvámos erhaltenen Karte [1] sowie der Statistiken betrachtet.

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[1] Nemesvamos, veszprémvármegyei nagyközség. Kataszteri birtokvázlata 1923 (1: 2 280).

Gebäude

Die beigegebene Karte (Abb. 5) stellt die Verteilung der Besiedlung im Jahre 1923 dar. Nach der Karte umfasst das Dorf 331 Wohn- und öffentliche Gebäude. Diese Zahl stimmt überein mit den statistischen Angaben, nach denen es in der Gemeinde im Jahre 1920 330 Wohnhäuser gegeben hat (PSH 1923). Es bestanden 5 öffentliche Gebäude, nämlich 2 Kirchen und 3 Schulen.

Die Wände aller Wohnhäuser waren aus Stein (PSH 1923). So verhielt es sich in den meisten nördlich des Balaton gelegenen Dörfern, die beinade jedes über Steinbrüche verfügten (vgl. Jankó 1906, S. 214). Im J. 1920 waren 177 der Wohnhäuser mit Stroh, 2 mit Schilf und die restlichen 151 mit Dachziegeln gedeckt.

In den Bauten spiegelten sich die Forderungen des vom Besitzer betriebenen Erwerbs. Im J. 1923 bezogen noch über 90 % der Dorfbewohner ihr Auskommen aus der Landwirtschaft. Zu den Gehöften gehörten ausser dem Wohnhaus als wesentlicher Teil auch die Wirtschaftsgebäude.

Das Wohnhaus umfasste oft nur zwei Räume, die Küche (*konyha*) und ein Zimmer (*szoba).* Die Anzahl der Räume war abhängig vom Vermögen des Besitzers, das in der Landwirtschaft oft zugleich auch die Betriebsgrösse kennzeichnete. Im J. 1935 umfassten 58 % der Landgüter einen Flächenraum von unter 10 Katastraljoch oder 5,8 ha (PSH 1938). Zu wohlhabenderen Betrieben gehörte im allgemeinen als dritter Raum eine Kammer (*kamra*). Eine nähere formale Musterung der Wohnhäuser ist nach vierzig Jahren nicht mehr möglich, denn die aus kalkhaltigem weichem Gestein aufgeführten Bauten sind in dieser Zeit manchen Instandsetzungen und Veränderungen unterzogen worden. Nach der von Jankó (1906) dargestellten ethnologischen Typeneinteilung für das Balaton-Gebiet sind die Wohnhäuser des Dorfes Nemeszvámos grösstenteils vom sog. ungarischen, die Minderzahl vom sog. deutschen Typ.

Je nach der Lage der Wirtschaftsgebäude zu den Wohnhäusern lassen sich drei Haupttypen von Gehöften unterscheiden: 1) Die wichtigsten Wirtschaftsgebäude, wie Kuh- und Pferdestall, sind unmittelbar als Fortsetzung des Wohnhauses gebaut (Abb. 14). Derartige Gemeingehöfte sind im Dorfe die meisten Betriebe. Wohn- und Wirtschaftsgebäude sind jedoch beinahe immer durch eine dicke Mauer voneinander getrennt. Von den Wohnräumen aus besteht also keine unmittelbare Tür-

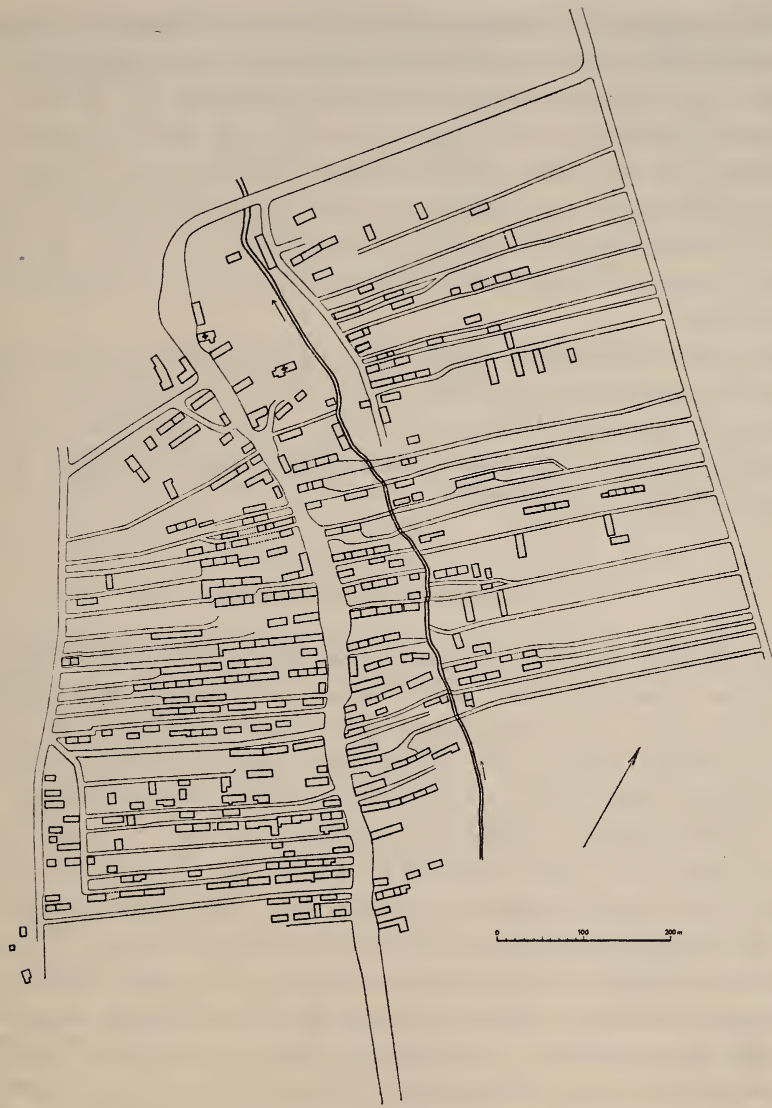

Abb. 5. Die Verteilung der Besiedlung im Dorfe Nemesvámos im J. 1923. Mit gestrichelter Linie sind die grössten Wirtschaftsgebäude der Gehöftreihen gezeichnet.

verbindung nach dem Pferde- oder Kuhstall, vielmehr gelangt man in diese nur vom Hofplatz aus. Auch ist das Dach der Gemeingehöfte meist nicht einheitlich, sondern das der Wirtschaftsgebäude ist niedriger. Ty-

pisch ist es, dass die verschiedenen Teile des Gemeingehöftes einer die Fortsetzung des anderen ist, nur sehr selten bilden sie miteinander einen Winkel. Die kleinsten Wirtschaftsgebäude dagegen, wie Keller, Holzschuppen, Hühnerstall usw., stehen jedes für sich an den Rändern des Hofplatzes. 2) Bei dem zweithäufigsten Gehöfttyp sind Wohn- und Wirtschaftsgebäude voneinander getrennt. Auch dabei stehen die wichtigsten Wirtschaftsgebäude in einer Reihe (Abb. 11 und 12). 3) Nur auf einigen wenigen Gehöften sind alle Teile jeder für sich auf dem Grundstück erbaut.

Von den dargestellten Gehöfttypen ist der erste in den mittleren Teilen des Dorfes am häufigsten, aber randwärts werden die Gehöfte mit getrennt stehenden Gebäuden häufiger. Diese räumliche Verteilung schliesst sich eng an die allgemeine Gruppierung der Gehöfte und die auf sie einwirkenden Faktoren.

Gruppierung der Gehöfte

Die Gehöfte des Dorfes Nemesvámos sind an den rechtwinklig zur Hauptgasse (Kossuth utca) verlaufenden Seitengassen grösstenteils so angeordnet, dass die Längsrichtung der Gebäude parallel zu den Seitengassen verläuft (Abb. 13). Diese sehr nahe beieinander gelegenen Seitengassen nennt man im Dorfe *köz* (= Spalt; Zwischenraum). Die von den Seitengassen begrenzten Landstreifen sind in kleine Grundstücke eingeteilt. Diese sind oft so klein, dass die darauf erbauten Gehöfte unmittelbar aneinander gereiht sind. Praktisch bedeutet dies, dass die Gemeingehöfte lange Gehöftreihen bilden, in denen Wohn- und Wirtschaftsgebäude miteinander abwechseln. Bei den Gehöften mit getrennten Gebäuden wiederum stehen die Wohnhäuser in einer Reihe, und die ihnen gegenüber jenseits der Gasse errichteten Wirtschaftsgebäude bilden eine gleichgerichtete Bautenreihe (Abb. 11 und 12). Das Aussehen der Gebäudereihe wird durch die für sie von den Dorfbewohnern angewandte Bezeichnung *vonat* (= Zug) veranschaulicht. Da die Grundstücke schmal sind, bilden die Gassen zugleich einen den Gehöften gemeinsamen langen Hofplatz.

In der folgenden Tabelle ist die Verteilung der Gehöfte von Nemesvámos auf Gehöftreihen (im J. 1923) wiedergegeben:

Anzahl der Gehöfte in den Gehöftreihen	Zu den Gehöftreihentypen gehörende Gehöfte		Anzahl der Gehöftreihentypen
	Anzahl	%	
1	158	47,7	158
2	52	15,7	26
3	48	14,5	16
4	40	12,1	10
5	25	7,6	5
6			
7			
8	8	2,4	1
	Zus. 331	100,0	

Im J. 1923 waren also über die Hälfte (52,3 %) der Gehöfte mit einem oder mehreren Gehöften (oder Wohnhäusern) zusammengebaut. Die längste Gehöftreihe umfasste 8 Gehöfte. Meistens waren die einzelnen Gehöftreihen nur durch eine kleine unbebaute Fläche voneinander getrennt. Die Menge der langen Gehöftreihen ist in der Nähe der Hauptgasse am grössten und verringert sich im Anstieg auf die Talhänge. An den Rändern des Dorfes sind die getrennt stehenden Gebäude am häufigsten.

Die Naturverhältnisse sind als einer der in der Anordnung der Besiedlung sich auswirkenden Faktoren zu beachten. Die Talsohle ist vor allem vom Blickpunkt der Wasserzufuhr eine höchst günstige Gegend gewesen. Aus topographischen Gründen wandte sich die Landstrasse der Talsohle zu. Da die Felder der Betriebe im allgemeinen über die ganze Gemeinde verstreut lagen, wollten die Bauern natürlich möglichst nahe an die Landstrasse herankommen. Längs der Strasse konnte man Vieh und Arbeitsgerät leicht auf die eigenen Felder schaffen. Diese vorwaltende Forderung des Erwerbs, sich möglichst nahe bei seinen Äckern niederzulassen, bedeutete in Nemesvámos, möglichst nahe der Landstrasse zu wohnen. In der Anordnung der Besiedlung ist denn auch deutlich der anziehende Einfluss der auf der Talsohle verlaufenden Landstrasse, d.h. der Hauptgasse, zu erkennen.

In der Gruppierung der Gehöfte spiegeln sich auf der anderen Seite historische Gegebenheiten. Zu den ältesten der Gehöfte gehören die in unmittelbarer Nähe der Hauptgasse errichteten Reihen, zu den jüngsten wiederum die an den Rändern des Dorfes gelegenen Gehöfte mit getrennten Gebäuden. Dies lässt sich sowohl aus dem Baustil als

auch aus den im Giebel vieler Gebäude vermerkten Baujahren schliessen. Das Entstehen der alten Gehöftreihen ist denn auch im Lichte der damals herrschenden Verhältnisse zu verstehen.

Wie oben bereits angeführt (S. 14), zahlten die Bauern von Nemesvámos früher Steuer einzig an die Adeligen von Veszprém. Nach einer im Dorfe bewahrten Überlieferung wurde gemäss der nach der Hauptgasse sich öffnenden Tore *(kapu)* Steuer entrichtet. Je Tor war eine gleich hohe Steuer zu zahlen. Dies reicht zurück in Zeiten, als Nemesvámos noch ein Reihendorf war, wo die Häuser einzeln an der Hauptgasse standen. Die Grundstücke der Häuser setzten sich in schmalen gleichgerichteten Streifen im Tale hangaufwärts fort. Damals war jedes Haus, nach dem im Balaton-Gebiet allgemeinen Brauch, mit einem Zaun umgeben, in den man nur durch ein nach der Hauptgasse sich öffnendes Tor gelangte (vgl. Jankó 1906, S. 188—190, 203). Je Tor gab es anfangs nur ein Haus, auf das die für sie zu zahlende Steuer also in seiner Ganzheit entfiel. Bei zunehmender Besiedlung suchte man die Steuerlast jedoch zu umgehen, indem man ein neues Haus als Fortsetzung des alten erbaute. So brauchte man kein neues Tor zu bauen noch zugleich mehr Steuern zu zahlen. Auch verminderte sich die Steuerlast der alten Gehöfte, da sich die für jedes Tor vorgeschriebene Steuer auf mehrere Betriebe verteilte. Besonders die erwachsenen Kinder der Familie erbauten beinahe immer ihr Haus als Fortsetzung ihres Elternhauses. Auch heute noch sind die meisten Bewohner derartiger Gehöftreihen miteinander verwandt. So tragen z.B. in der Gehöftreihe, in der im J. 1923 8 Gehöfte nebeneinander lagen, alle Bewohner auch heute noch den Familiennamen Kozma. Die der Gehöftreihe entsprechende Seitengasse nennt man auch Kozma-köz.

Auf Verwandtschaft mag sich denn auch das jahrhundertelange Fortbestehen der vom Standpunkt selbständigen Wohnens ungünstigen Gehöftreihen gründen. Auf der anderen Seite kann das Beibehalten der langen Gehöftreihen als Beweis für den Stillstand der allgemeinen Entwicklung des Dorfes und seine Rückständigkeit angesehen werden. Die Einwohnerzahl des Dorfes war bis 1923 schon jahrzehntelang beinahe unverändert geblieben oder eigentlich sogar etwas gesunken (s. S. 16). Diese Entwicklung spiegelt sich auch in der Anzahl der Wohnhäuser der Gemeinde. Im Jahre 1847 gab es in der Gemeinde 403, 1900 346, 1910 342 und 1920 330 Wohnhäuser (Illésfalvi 1954; MSK 1912; PSH 1923; vgl. auch Laczkó & Rhé 1912, Abb. 1). Die

Bautätigkeit des Dorfes beschränkte sich in erster Linie nur auf das Instandsetzen alter Häuser. Die wenigen neuen Häuser, die Anfang des Jahrhunderts erbaut wurden, errichtete man in den Randteilen des Dorfes, gesondert von den langen Gehöftreihen. Hier bestand nämlich die Möglichkeit, ein grösseres Grundstück zu erhalten, das auch für einen Hausgarten reichte.

ENTWICKLUNG DER BESIEDLUNG VON 1923—1963

Oben hat sich herausgestellt (S. 14), dass die Einwohnerzahl von Nemesvámos vom J. 1920 bis zum J. 1960 nur um 147 Personen gestiegen ist. Eine grössere Wandlung hat sich in der erwerbsmässigen Gliederung der Bevölkerung vollzogen. Im J. 1920 erhielten 91,1 % der gesamten Bevölkerung ihr Auskommen in der Landwirtschaft, im J. 1960 nur noch 59,5 % (PSH 1923; KSH 1962). In jener Zeit ist ausserdem der Übergang zum sozialistischen System erfolgt. Somit ist zu verstehen, dass auch in der Verteilung der Besiedlung in jener Vierzigjahresperiode bedeutende Wandlungen eingetreten sind.

Die Menge der Wohnhäuser im Dorfe hat gewechselt wie folgt: 1920 330 (PSH 1923), 1930 322, 1954 348 (Illésfalvi 1954) und 1960 415. In die Zahlen gehen 5—10 öffentliche Gebäude ein, von denen die meisten auch zum Wohnen benutzt werden. Die dargestellten Zahlen vermitteln jedoch kein ganz richtiges Bild von den in der Besiedlung vor sich gegangenen Veränderungen, denn gleichzeitig sind viele Häuser gebaut und alte abgerissen worden.

In der Zeitfolge 1923—1963 haben sich in den Anzahlen der Wohnhäuser und öffentlichen Gebäude folgende Wandlungen vollzogen:

neue Häuser gebaut	125
alte Häuser niedergerissen	41
Zunahme der Häuserzahl von 1923—63	84
Häuser 1923	331
Gebäude insgesamt 1963	415

Fünf der neuen Häuser sind auf dem Baugrund eines nach 1923 abgebrochenen Gebäudes errichtet worden. Ausserdem hat man bei elf der vor 1923 erbauten Wohnhäuser bedeutende und gründliche Instandsetzungen vorgenommen. Unter den ausgeschiedenen Wohnhäusern

finden sich wiederum 9 solche Bauten, die nicht abgebrochen, sondern für eine Nutzung als Wirtschaftsgebäude eingerichtet worden sind.

Alle in der Verteilung der Besiedlung zwischen 1923 und 1963 eingetretenen Veränderungen gehen aus der beigefügten Karte hervor (Abb. 6). Ausser den Wirtschaftsgebäuden der Genossenschaftsbetriebe sind auch in die Karte die bei den Wirtschaftsgebäuden der Gemeingehöfte vorgekommenen Veränderungen eingetragen, soweit sie ein Unterbrechen von Gehöftreihen bewirkt haben. Ausserdem sind die Nebengebäude sowie die Maschinenstation des Genossenschaftsbetriebes in der Karte angegeben.

Das Entstehen von Eigenheimbesiedlung

Mit Hilfe der im Giebel der Gebäude vermerkten Jahreszahlen und durch Befragungen ist es möglich, genauere Angaben über die Erbauungsjahre der Häuser zu erhalten. Vor dem Zweiten Weltkrieg, in den Jahren 1923—1938, war die Bautätigkeit sehr gering. Alte Häuser schwanden in grösserer Zahl, als neue gebaut wurden. Dagegen wurden alte Gebäude fortfahrend Instandsetzungsarbeiten unterzogen. Dies wird auch dadurch bewiesen, dass sich in der Zehnjahresperiode von 1920—1930 die Anzahl der stroh- und schilfgedeckten Häuser von 179 auf 106 verringerte, aber die der mit Dachziegeln gedeckten von 151 auf 216 stieg (PSH 1923; Illésfalvi 1954).

Nach dem Zweiten Weltkrieg belebte sich die Bautätigkeit so sehr, dass bis zum Jahre 1950 durchschnittlich zwei neue Häuser im Jahre erbaut wurden. Sie gehörten des weiteren meistens der Agrarbevölkerung. Die neuen Häuser wurden grösstenteils verstreut in den östlichen Randteilen des Dorfes, etwas gesondert von der alten dichten Besiedlung, errichtet. Die Häuser dieser Zeitfolge haben ein bedeutend grösseres Grundstück als die alten in der Dorfmitte. Dem Gehöfttyp nach sind die Anwesen eingezäunte Einzelgehöfte, bei denen die Wirtschaftsgebäude getrennt auf dem Grundstück stehen.

→

Abb. 6. Die Entwicklung der Besiedlung von Nemesvámos 1923—1963. — 1. Neues Wohn- oder öffentliches Gebäude. 2. An Stelle eines alten Hauses errichtetes neues Wohn- oder öffentliches Gebäude. 3. Verschwundenes Wohnhaus. 4. Wohnhaus in ein Wirtschaftsgebäude umgearbeitet. 5. Wirtschaftsgebäude des Genossenschaftsbetriebes. 6. Durch Schwinden eines Wirtschaftsgebäudes verursachte Lücke in der Gehöftreihe.


1
2
3
4
5
6
0
100
200m

Die Bautätigkeit nach 1923 ist zum grössten Teil erst nach 1950 vor sich gegangen. Besonders zahlreich sind in den allerletzten Jahren Häuser entstanden. Diese starke Zunahme im Bauen ist auf die Nähe der Stadt Veszprém und die von ihr gebotenen neuen Arbeitsmöglichkeiten zurückzuführen (vgl. S. 17). Das Dorf hat sich allmählich aus einem reinen Agrardorf zu einem Zwischentyp zwischen Landwirtschaftsdorf und Wohnvorstadt entwickelt, dessen berufstätige Bevölkerung sich zu etwa 1/3 täglich zur Arbeit in die Stadt begibt. Demgemäss sind fast alle neuen Gebäude von in der Stadt Gewerbetreibenden bewohnte Häuser, denen Wirtschaftsgebäude meist fehlen. Im Gegensatz zu den alten, aus Kalksteinblöcken aufgeführten Häusern der Dorfmitte sind die neuen hauptsächlich aus gebrannten Lössziegeln aufgebaut. Die Häuser sind kleine Einfamilien-Eigenheime.

Für die Lage der von Pendlern bewohnten Häuser ist es bezeichnend, dass sie alle ihren Platz an der nach der Stadt führenden Landstrasse gefunden haben. Im Jahre 1955 wurden die Verkehrsverbindungen des Dorfes dadurch verbessert, dass man einen Anschlussweg von den nördlichen Dorfteilen unmittelbar bis zu der nach Veszprém führenden Landstrasse baute. Zu beiden Seiten dieses Anschlussweges wurden als erste grössere Eigenheimgruppe in den Jahren 1955—57 15 Häuser errichtet (Abb. 9). Diese entstanden also in einem Gebiet, wo wegen der durch den Felsgrund verursachten Dürre (vgl. S. 9) keine alte Agrarbesiedlung aufzukommen vermocht hatte. Denen, die in der Stadt ihr Gewerbe betreiben, bedeutet die Wasserfrage nicht so viel wie den Landwirten, deren Wasserverbrauch durch das Vieh wesentlich vermehrt wird. Besonders nach der Kanalisation, als das um das Haus herum liegende Privatland auf einige Ar eingeschränkt wurde, verminderte sich der Wasserbedarf sogar noch weiter. Somit kann das Verbrauchswasser leicht durch Tragen auch aus etwas weiterer Entfernung herbeigeschafft werden.

Nach Vollendung der obengenannten Gruppe von 15 Häusern ist die Bautätigkeit des weiteren gebietweise vor sich gegangen. Im Ostteil des Dorfes, an der Landstrasse, ist eine lange Häuserreihe entstanden, in der die der Hauptlandstrasse nächstgelegenen Bauten am ältesten sind (Abb. 18). Diese Häuserreihe liegt auf dem trockenen Talhang. An ihrem Nordende, neben der Wegkreuzung, steht jedoch ein in den 1950er Jahren erbauter Wasserturm, von dem aus das Wasser nach seinen am Wege gelegenen Verteilungspunkten hat geleitet werden

können. Nur bei zweien der dem Wasserturm nächstgelegenen Häuser hat die Wasserleitung bis hinein verlegt werden können.

Das dritte zusammenhängende neue Wohngebiet liegt im Südteil des Dorfes an der Hauptlandstrasse (Abb. 19). Die Grundstücke dieser Häuser sind von der fruchtbaren Ackerfläche getrennt. Bei dem ersten, also der Dorfmitte am nächsten gelegenen neuen Haus befindet sich ein Brunnen, aus dem das Wasser geholt wird.

Die starke Bautätigkeit der letzten Jahre ist also in ihrer Ganzheit zwar auf die Ränder des alten dichtbesiedelten Dorfes, aber doch auf gute Verkehrsverbindungen angewiesen gewesen. Die Pendler fahren grösstenteils mit Linienbussen. Ausserdem fährt man in recht reichlichem Masse mit Motorrädern, aber im ganzen Dorfe gibt es nur 7 Personenkraftwagen.

Im ganzen gesehen, baute man bis zum J. 1950 die Häuser infolge Privatbesitzes im allgemeinen verstreut in den Randteilen des Dorfes, während hingegen die neuen, regelmässig bebauten Eigenheim-Siedlungsgebiete erst ein Ergebnis der letzten Jahre sind. Dies liegt in erster Linie an der planmässigen Lenkung der Bautätigkeit, denn nach der 1958 eingeleiteten Verstaatlichung des Bodens hat der Staat alle Bodennutzung im Dorfe bestimmt. Daher sind auch die Wohngrundstücke nach Bedarf systematisch in einheitlichen, dem Zweck entsprechenden Siedlungsgebieten verteilt worden.

Auflockern der Dorfmitte

In den engen mittleren Teilen des Dorfes sind sehr wenig neue Häuser erbaut worden. Im Gegenteil, in diesem Bereich hat seit 1923 infolge des Abbrechens alter Gebäude die Anzahl der Häuser beträchtlich abgenommen. Die Gehöftreihen gereichten einst zu dem Nutzen, dass man durch sie die Steuerlast zu umgehen vermochte. Nach aufhörendem Einfluss dieses zur Verdichtung der Besiedlung beitragenden Faktors suchte man verständlicherweise jene enge und für die gegenwärtigen Verhältnisse ungeeignete Wohnform aufzugeben. Somit gehörten zu den aus zwei oder mehr Gehöften bestehenden Reihen im J. 1963 nur noch 41,8 % aller Gehöfte des Dorfes (1923 52,3 %). Doch äussert sich das Auflockern alter Teile des Dorfes nicht allein im Abbruch von Häusern, sondern auch in der durchschnittlichen Verminderung der Einwohnerzahl der alten Häuser. Im J. 1923 lebten

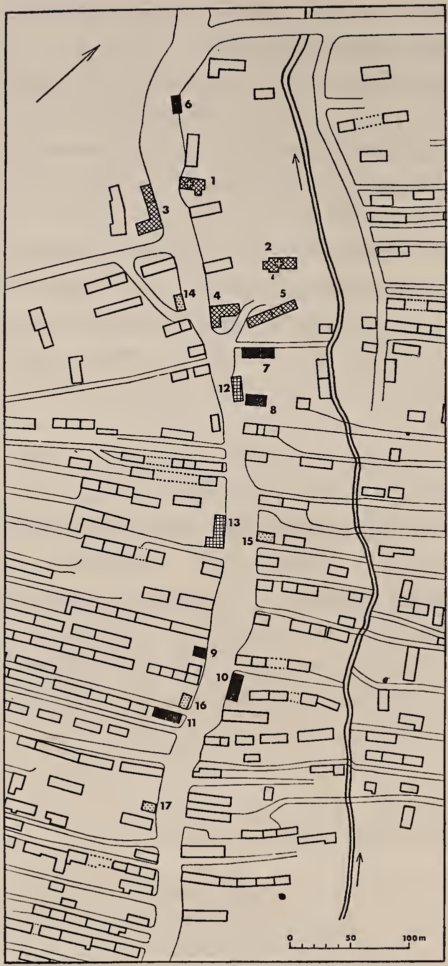

Abb. 7. Geschäfts-, öffentliche und In-
dustriegebäude von Nemesvámos im J
1963.

1. Kath. Kirche
2. Ref. Kirche
3. Volksschule
4. Volksschule
5. Volksschule
6. Bus-Wartehäuschen
7. Posthaus
8. Dorfkrug
9. Barbier-Frisiersalon
10. Gemischtwarenhandlung
11. Fleischladen
12. Gemeindehaus
13. Kulturhaus
14. Mühle
15. Schuhreparaturwerkstatt
16. Molkerei
17. Schmiede

im Dorfe etwa 4,5 Menschen je Haus, während sich 1963 die entsprechende Zahl nur noch auf 3,9 belief. Diese Verringerung in der Bewohnerdichte der Dorfmitte steht auch mit dem Wandel der Erwerbsstruktur gut im Einklang, denn die Mehrzahl der Bewohner alter Häuser schafft heutzutage als Arbeiter im Genossenschaftsbetrieb.

In der alten Dorfmitte haben sich jedoch Geschäfts- und öffentliche Gebäude so gut wie unverändert erhalten. Sie sind in der beigegebenen Karte dargestellt (Abb. 7). Im Sommer 1963 gab es im Dorfe nur ein betriebenes Geschäft (Abb. 10). Es liegt in der Hauptgasse des Dorfes, im Schwerpunkt der alten Besiedlung.

Es führt getrennt eine Gemischtwaren- und eine Lebensmittelabteilung. Jenseits der Gasse befindet sich ausserdem ein Fleischladen, aber er ist nur winters im Betrieb. In Anbetracht der Einwohnerzahl des Dorfes führt man erstaunlich wenig Geschäfte, was sich zum Teil durch die Nähe der Stadt Veszprém erklärt. Grosse Einkäufe tätigt man im Zusammenhang mit Arbeits- oder Einkaufsreisen in der Stadt. Sonstige Dienstleistungsformen vertritt das Posthaus; im Zusammenhang mit ihm hält an bestimmten Tagen ein Arzt seine Sprechstunde. Ausserdem finden sich im Dorfe ein Barbier-Frisiersalon, ein Dorfkrug (csárda) sowie ein Dorfschuster.

Die Verwaltung des Genossenschaftsbetriebes und zugleich auch des Dorfes hat ihren Sitz im Gemeindehaus. Neben diesem stehen die beiden alten Dorfkirchen, eine römisch-katholische und eine reformierte (Abb. 9 und 10). Sie sorgten früher auch für den Volksunterricht. In jene Zeit reicht auch die Lage der Volksschulen in der Nähe der Kirchen auf früheren Geländen der Kirchengemeinden zurück. Heute setzen die Schulen ihre Tätigkeit in ihren früheren Räumen fort, jetzt nur unter staatlicher Behörde. Die neueste Unterrichts- und Freizeitbetätigung ist vertreten durch das Kulturhaus (Abb. 17). Es bietet eine Bibliothek, Versammlungsräume und winters Filmvorführungen.

Im ganzen haben sich alle Geschäfts- und öffentlichen Gebäude längs der durch das Dorf verlaufenden Hauptgasse gesammelt, wenn auch nicht unbeträchtlich voneinander getrennt. Da die verschiedenen Tätigkeitsformen ohne Wettbewerber sind, hat auch dies nicht auf eine deutlichere Differenzierung der Ortsmitte hinwirken können.

Einfluss des Sozialismus

Die Ländereien von Nemesvámos wurden 1958 verstaatlicht. In der Gemeinde hatten jedoch schon seit 1949 zwei kleine Genossenschaftsbetriebe gearbeitet. Auf Vilmapuszta betätigte sich ein »Béke» benannter Genossenschaftsbetrieb, zu dem 9 Familien gehörten, und der Betrieb »Petőfi» beschäftigte 7 Familien aus dem zur Untersuchung vorliegenden Dorfe Nemesvámos. Augenblicklich bildet die Gemeinde Nemesvámos zusammen mit der südlich von ihr gelegenen Gemeinde Veszprémfajsz einen gemeinsamen grossen Genossenschaftsbetrieb. Die Einwohnerzahl von Veszprémfajsz beläuft sich auf nur 279 (1960), aber sein Flächenraum ist gross (2 040 Katastraljoch). Dies erweitert beträchtlich die Fläche, wohin sich die Bewohner des Dorfes Nemesvámos auf Arbeit zu begeben haben. Das administrative Zentrum (tanács székhelye) des von diesen zwei Gemeinden gebildeten Genossenschaftsbetriebes liegt in Nemesvámos (KSH 1963).

Das Zustandekommen des Genossenschaftsbetriebes bedingte auch eine Neuordnung der in der Landwirtschaft zu benutzenden Wirt-

schaftsgebäude. Im J. 1960 wurden die gemeinsamen Kuh- und Pferdestallgebäude des Betriebes fertig. Sie wurden nordwestlich des Dorfes, ausserhalb der eigentlichen Wohnbereiche, erbaut (Abb. 20). Ein Tiefbohrbrunnen verbürgt diesem früheren trockenen Wiesengebiet die Wassergewinnung. Eine andere zu dem grossen Genossenschaftsbetrieb wesentlich gehörende Bautengruppe besteht aus den Gebäuden einer Maschinenstation. Sie sind für Reparatur und Verwahrung lanwirtschaftlicher Maschinen errichtet worden. Die Maschinenstation liegt im nordöstlichen Teil des Dorfes, ander nach Veszprém führenden Stasse. Sie wirkte anfangs als Lagerungs- und Verteilungszentrum der Landwirtschaftsmaschinen mehrerer einzelnen Genossenschaftsbetriebe. In letzter Zeit ist jedoch jedem Genossenschaftsbetrieb das Recht erteil worden, eigene Maschinenstationen zu gründen, und infolgedessen ist die frühere Maschinenstation von Nemesvámos nur ein Zentrum für Maschinenreparatur geblieben. Die eigene Maschinenstation des Dorfes liegt heute gegenüber der zentralen Reparaturwerkstatt, auf der anderen Seite der Strasse.

Nach 1958 ist der Umfang des in Privatnutzung stehenden Bodens auf ein sehr geringes Mass beschränkt worden. Je männliche Person bekommt man an Boden etwa 0,25—0,50 ha, je weibliche und je Greis noch weniger. Die Menge des Privatviehes beschränkt sich auf eine Kuh, eine Ziege und ein Schwein nebst Ferkeln. Für das Federvieh bestehen keine Einschränkungen. Praktisch besteht wegen der kleinen Parzellen jedoch keine Möglichkeit, diese ganze zulässige Viehmenge zu halten. Besonders das Halten einer Kuh ist wegen Futtermangels schwer.

Der Übergang zum neuen Wirtschaftssystem hat jedoch nicht plötzlich eintreten können, zumal da die grossen Kuh- und Pferdestallgebäude des Genossenschaftsbetriebes erst allmählich fertiggestellt worden sind. Nach seiner Gründung wurde denn auch das Vieh anfangs in den früheren privaten Wirtschaftsgebäuden des Dorfes gepflegt. Tagsüber war die Rinderherde jedoch auf der gemeinsamen Weide, und abends wurde sie auf die Kuhställe des Dorfes verteilt. Nach Vollendung der Wirtschaftsgebäude des Genossenschaftsbetriebes ist die Viehpflege in diese verlegt worden. Doch gibt es auch heute noch hier und da in privater Pflege besonderes Vieh des Genossenschaftsbetriebes.

Obgleich seit der Umstellung zum sozialistischen System erst fünf Jahre vergangen sind, lassen sich die Folgen auf den Gehöften des alten Dorfteils bereits erkennen. Früher bildete jedes Landbaugehöft seine eigene betriebliche Ganzheit, zu der als wesentlicher Teil sowohl die Wohn- als auch die Wirtschaftsgebäude gehörten. Nach der Gründung des Genossenschaftsbetriebes hat sich der Charakter der von der Agrarbevölkerung zu leistenden Arbeit völlig verändert. Der frühere Bauer ist Landarbeiter geworden, der seine eigene an eine bestimmte Arbeitszeit gebundene Sonderaufgabe im Dienste des Genossenschaftsbetriebes zu leisten hat. So besteht z.B. zwischen dem in der Stadt Veszprém tätigen Gelegenheitsarbeiter und dem in Dienste des Genossenschaftsbetriebes stehenden Landarbeiter in bezug auf das Wohnen kein grundsätzlicher Unterschied mehr. Da die Möglichkeiten des Landarbeiters für Privatviehhaltung sehr begrenzt sind, ist das Vorhandensein der eigenen Kuhstall-, Pferdestall-, Lager- u.a. Wirtschaftsgebäude überflüssig geworden.

Einer der auffallendsten Züge der alten Teile des Dorfes Nemesvámos besteht denn auch heute darin, dass die früheren Wirtschaftsgebäude entweder verfallen oder ganz verschwunden sind (Abb. 12 und 14). Die geringe Menge an Schweinen und Federvieh, die in den Privatwirtschaften gehalten werden kann, bedarf keiner grossen Pflegeräume.

ZUSAMMENFASSUNG

Untersuchungsgegenstand ist das ungarische Dorf Nemesvámos, das im Süd-Bakony gelegen ist. Der Zweck der Arbeit ist es, Aufbau und Entwicklung der Dorfbesiedlung klarzulegen. Die Feldarbeiten der Untersuchung sind im Sommer 1963 ausgeführt worden.

Die Lage des Dorfes Nemesvámos hängt eng zusammen mit der Wasserfrage, die ihrerseits durch den geologischen und tektonischen Aufbau des Gebietes bedingt ist. Das Dorf liegt in einem mit dem Einbruchtal Veszprém-Tapolca sich verbindenden kleineren Tal, in dem sowohl die Grundwasser- als auch die Bodenverhältnisse günstiger als in der nahen Umgebung sind.

Die Entwicklung der Besiedlung des Gebietes lässt sich anhand von archäologischen Funden und von Literaturbelegen bis in die römische Zeit zurücksverfolgen. In römischer Zeit hatte sich die *Villa*-Siedlung Balácapuszta um eine Quelle angeordnet, rd. 800 Meter vom

Rande des gegenwärtigen Dorfes nach Südosten. Um das Jahr 1000 hatte sich die Siedlung in zwei Dörfer um Quellen (Nagykút und Kiskút) herum geteilt. Die eine der Quellen liegt ganz am Südrande des gegenwärtigen Dorfes.

Bei drohender Türkengefahr schlossen sich die Dörfer im 16. Jahrhundert aus Verteidigungsgründen zu einer Ganzheit zusammen, die jedoch um 1552 vernichtet wurde. Erst nach beendeter Türkenzeit (1610) begann sich das Dorf an seiner jetzigen Stelle zu entwickeln.

Die ersten Häuser wurden an der auf der Talsohle verlaufenden Landstrasse erbaut. Auf die spätere Entwicklung der Besiedlung wirkte die Sonderstellung des Dorfes als sog. *curialis* ein. Mit anderen Worten, das Dorf zahlte Steuer nur an Adelige. Die Steuererhebung erfolgte nach der Anzahl der nach der Hauptgasse des Dorfes sich öffnenden Tore. Diese Besteuerungsweise verhinderte das Ausdehnen der Dorfbesiedlung in der Richtung der Hauptgasse, d.h. das Entstehen neuer steuerpflichtiger Tore. Bei anwachsendem Dorf umging man die Steuerlast, indem man die neuen Häuser hinter den alten Toren erbaute. Dies sowie das Beschränken des für Besiedlung am besten geeigneten Bodens auf eine verhältnismässig schmale Fläche führte zu der Entstehung langer Gehöftreihen.

Über die Einwohnerzahl des Dorfes haben sich bis aus dem 18. Jahrhundert Angaben erhalten. In der Menge der vorwiegend landwirtschaftlichen Bevölkerung des Dorfes sind während der letzten drei Jahrhunderte nur geringe Veränderungen eingetreten. So haben sich die Gehöftreihen des Dorfes und überhaupt sein dichtes Gefüge bis zum Zweiten Weltkrieg fast unverändert erhalten.

Nach dem Zweiten Weltkrieg hat sich das Dorf zu einem Zwischentyp zwischen Landwirtschaftsdorf und Wohnvorstadt entwickelt. Von der berufstätigen Bevölkerung des Dorfes begibt sich etwa 1/3 auf Arbeit ausserhalb der eigenen Gemeinde, hauptsächlich in der nahen Stadt Veszprém Ausserdem ist das Dorf allmählich zum sozialistischen Wirtschaftssystem übergegangen. Diese grossen Wandlungen spiegeln sich natürlich auch in der Besiedlung.

Zum Verständnis der abgelaufenen Entwicklung wird zunächst die Verteilung der Besiedlung im J. 1923 betrachtet. Danach wird dargelegt und verglichen, welche Veränderungen in dieser Verteilung bis 1963 vor sich gegangen sind. Dadurch ist es möglich, über die Besiedlung des Dorfes die auf der beigegebenen Karte (Abb. 8) dargestellte

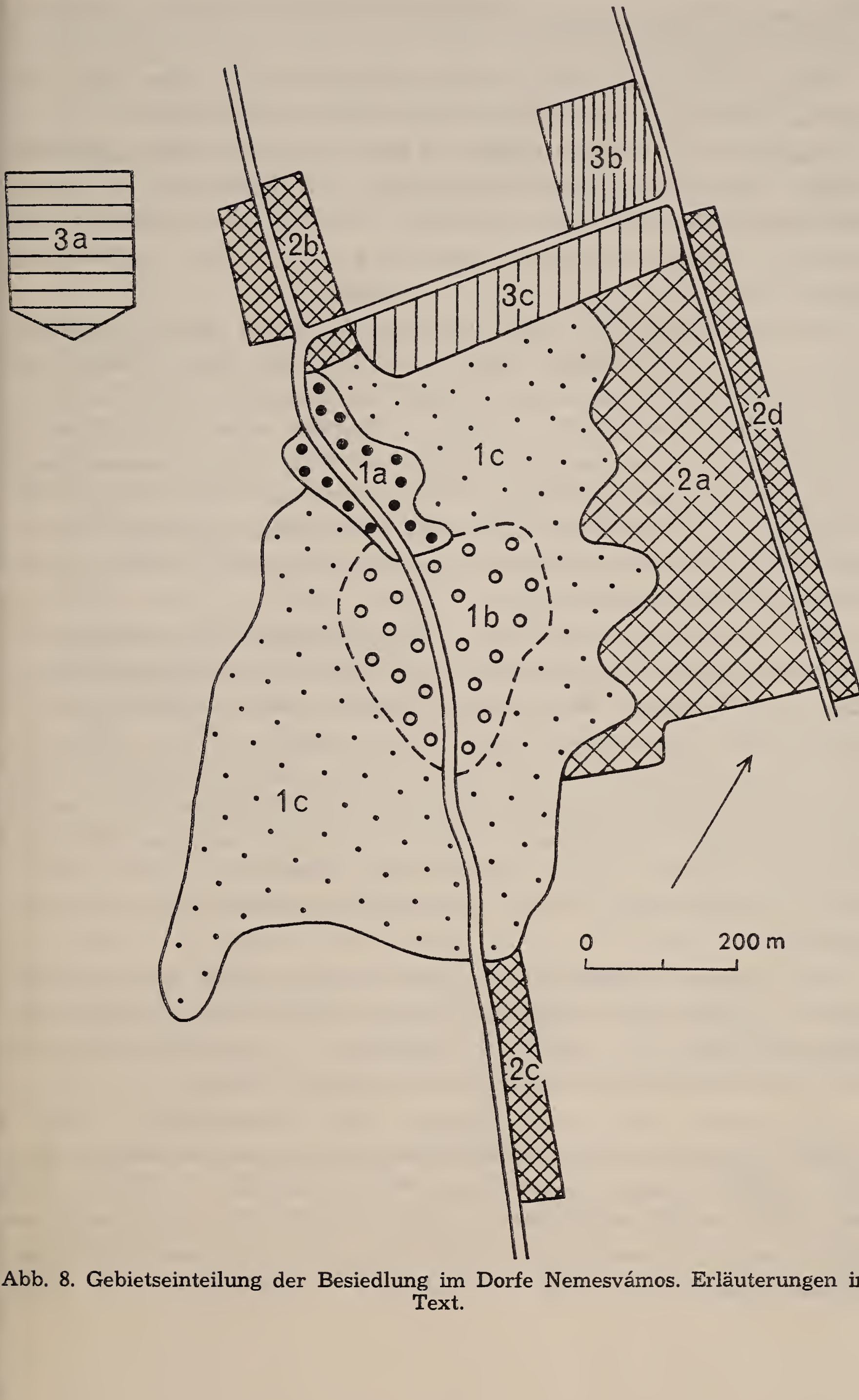

Abb. 8. Gebietseinteilung der Besiedlung im Dorfe Nemesvámos. Erläuterungen im Text.

Gebietseinteilung zu fassen. Die Ziffern im Text verweisen auf die auf der Karte angegebenen Gebiete.

Zunächst kann die Besiedlung in einen alten und einen neuen Teil getrennt werden, die sich deutlich voneinander unterscheiden.

Der alte Teil (1) umfasst im Dorfe ein schon 1923 besiedeltes Gebiet. Dieses beschränkt sich auf den vom Blickpunkt der Agrarbesiedlung günstigsten Teil des Tales. Sowohl im Norden als auch auf den Talhängen reicht die Besiedlung in eine Zone, wo trockene Wiesen einsetzen.

1 a. Der älteste Teil des Dorfes und zugleich seine funktionelle Mitte liegen im nördlichen Ende des alten Teiles. Hier befinden sich die Kirche der Katholiken und die der Reformierten, die Volksschulen, Gemeindehaus, Post und Dorfkrug. Obgleich das einzige Geschäft des Dorfes etwas weiter entfernt liegt, rd. 200 m südlich des Gemeindehauses, hat sich das betreffende Gebiet als zentralste Zusammenkunftsstelle des Dorfes erhalten. Darin hat sich auch ausgewirkt, dass die Haltestelle des nach Veszprém gerichteten örtlichen Verkehrs gerade in diesem Gebiet gelegen ist.

1 b. An das obige administrative und funktionelle Zentrum des Dorfes schliesst sich unmittelbar seine älteste Besiedlung. Typisch für diesen Raum sind heute die schwindenden Gehöfte und als Folge davon die lückenhaften alten Gehöftreihen. Hier befindet sich die Hälfte der im Dorfe in den Jahren 1923—1963 abgebrochenen und der in derselben Zeit in Wirtschaftsgebäude umgearbeiteten Häuser. Auf die Verringerung der Bewohnerdichte dieses Gebietes hat ausserdem das reichliche Verziehen junger, arbeitsfähiger Bevölkerung entweder aus der Gemeinde oder in neue Wohngebiete des eigenen Dorfes hingewirkt.

1 c. An das vorhergehende Gebiet schliessen sich ohne deutliche Grenze die altersmässig jüngsten Randbezirke des alten Dorfteils. Vorherrschend sind hier gepflegte Gehöftreihen oder Einzelgehöfte, die die jüngste Besiedlung des gesamten alten Teiles vertreten.

Der grösste Teil der Bevölkerung der Wohngebiete 1b und 1c erhält heute sein Auskommen im Dienste des Genossenschaftsbetriebes. Die in Privatnutzung gewesenen Wirtschaftsgbäude verfallen und schwinden heutzutage Schritt für Schritt, da die dem Privatbesitz von Boden und Vieh auferlegten Beschränkungen sie grösstenteils überflüssig machen.

Der neue Teil (2 und 3) unterscheidet sich scharf vom alten. Die Bautätigkeit hat sich nach 1923 fast ausschliesslich dem neuen Teil zugewandt. Im alten Teil des Dorfes sind in den Jahren 1923—63 nur 28 Wohnhäuser erbaut worden, während gleichzeitig im neuen 97 Häuser errichtet worden sind. Der Unterschied zwischen dem neuen und alten Teil des Dorfes wird noch dadurch gesteigert, dass die Bautätigkeit vor dem Zweiten Weltkrieg jahrzehntelag sehr gering gewesen war.

Auf Grund der Bodennutzung können die nach 1923 mit Häusern bebauten Flächen in Wohngebiete (2) und in Wirtschaftsbauten-Gebiete des Genossenschaftsbetriebes (3) eingeteilt werden.

2 a. Auf den alten Teil des Dorfes beschränkt sich im Westen das hauptsächlich zwischen 1923 und dem Zweiten Weltkrieg bebaute Gebiet. Die Häuser sind von Zäunen umgebene Einzelgehöfte. Die Erbauer waren selbständige Landwirte oder Lohnarbeiter (gegenwärtig im Dienste des Genossenschaftsbetriebes oder städtischer Gewerbe). Die Häuser stehen dort ziemlich verstreut, so dass man schon damals die enge Bauweise, wie sie im alten Dorfteil bestand, aufzugeben suchte. Auf der anderen Seite haben auch die zur Zeit des Bauens bestehenden Grundbesitzverhältnisse sowie freie Nachfrage und freies Angebot im Parzellenhandel das Aufkommen von Einzelgehöften gefördert.

2 b, 2 c und 2 d. Nach dem Zweiten Weltkrieg sind drei einheitliche Eigenheim-Siedlungsgebiete entstanden, deren Bewohner sich grösstenteils nach Veszprém auf Arbeit begeben. Demgemäss hat man die Häuser an den nach der Stadt führenden Strassen zu errichten gesucht. Sie sind aus gebrannten Ziegeln erbaut und physiognomisch durchaus von den Kalksteinhäusern des alten Dorfteils unterschieden. Die Gehöfte umfassen im allgemeinen nur ein Wohnhaus. Die Häuser stehen an den Strassen in geraden Reihen derart, dass das Erbauen systematisch von der Dorfmitte (2 b, 2 c) und bei Gebiet 2 d von der Strassenkreuzung aus fortgeschritten ist. Die Eigenheime sind grösstenteils nach 1958 erbaut worden, d.h. in einer Zeit, als der Staat die Bodennutzung gesteuert hat.

3 a. Das Gründen des Genossenschaftsbetriebes setzte gemeinsame Kuh- und Pferdestallgebäude voraus. Sie wurden ausserhalb des Dorfes errichtet. Bei der Wahl der Stelle spielte die Wasserzufuhr eine wichtige Rolle. Das Anlegen von Tiefbohrbrunnen war im nordwestlichen Teil am günstigsten. Auch war das Gebiet mit Rücksicht auf das

Weiden des Viehes vorteilhaft, da der grösste Teil der Wiesen- und Weidenflächen des Genossenschaftsbetriebes auf dieser Seite des Dorfes liegt.

3 b und 3 c. Zur Zeit der Gründung des Genossenschaftsbetriebes vollendete man im nordöstlichen Teil des Dorfes, an guten Verkehrsverbindungen die zentrale Maschinenstation (3 b), deren Aufgabe es war, den Genossenschaftsbetrieben von Nemesvámos wie auch der nächsten Umgebung Landwirtschaftsmaschinen zur Verfügung zu stellen. In letzter Zeit ist jedem Genossenschaftsbetrieb das Recht erteilt worden, eine eigene Maschinenstation zu gründen. Bei der eigenen Maschinenstation (3 c) von Nemesvámos waren im Sommer 1963 die Neubauten in der Vollendung begriffen. Die frühere zentrale Maschinenstation dient als zentrale Reparaturwerkstatt.

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BILDBEILAGE

(Abb. 9—20)

Abb. 9. Am Rande des Dorfes sieht man bei Eintreffen von Norden her eine Tafel, auf der die landwirtschaftliche Erzeugung des Genossenschaftsbetriebes im vorhergehenden Jahre engegeben ist. Die nächstgelegenen Wohnhäuser sind in den Jahren 1955—57 erbaut worden. Im Hintergrunde links die reformierte, rechts die katholische Kirche.

Abb. 10. Die Hauptgasse (Kossuth utca). Das erste Haus rechts ist die Gemischtwarenhandlung. Im Hintergrunde die reformierte Kirche.

Abb. 11. Im alten Teile des Dorfes sind die Gehöftreihen vorherrschend. In der auf dem Bilde wiedergegebenen Gehöftreihe stehen nur Wohnhäuser. Das zweite Haus in der Reihe wird gerade instand gesetzt. Wirtschaftsgebäude s. folgendes Bild.

Abb. 12. Mit der Häuserreihe von Abb. 11 verbindet sich auf der anderen Seite des gemeinsamen Hofplatzes oder der Gasse eine Reihe von Wirtschaftsgebäuden. Ihre Kuh- und Pferdestallgebäude, nunmehr zwecklos, verfallen.

Abb. 13. Die Häuserreihen des alten Dorfteils erstrecken sich rechtwinklig zur Hauptgasse im Tal hangaufwärts. Auf dem Bilde die Koszma-köz (= Koszma-Gasse), die ihren Namen dadurch erhalten hat, dass alle Bewohner der sie begleitenden Häuserreihe Koszma heissen und miteinander verwandt sind. In der Reihenordnung ist das zweite Gehöft in den letzten Jahren abgebrochen worden.

Abb. 14. Bei vielen Gehöften im alten Dorfteil sind die Wirtschaftsgebäude als unmittelbare Fortsetzung des Wohnhauses errichtet. Heute schwinden Kuh- und Pferdeställe.

Abb 15. Morgens um 6.00 Uhr versammeln sich die Mitglieder des Genossenshaftsbetriebes an der Hauptgasse (Bild: vor dem Barbier-Frisiersalon), wo man Nachrichten verliest.

Abb. 16. Morgens um 6,25 Uhr. Von den Seitengassen des Dorfes her sammelt sich das Vieh auf der Hauptgasse, von wo aus es auf die Weide getrieben wird. Die junge Arbeitskraft des Dorfes begibt sich grösstenteils mit dem Linienbus zum Erwerb in die Stadt. Im Hintergrunde Frauen, bereit zur Abfahrt nach der Stadt Veszprém, wo sie auf dem Markt die auf ihren Privatparzellen geernteten landwirtschaftlichen Erzeugnisse abzusetzen gedenken.

Abb. 17. Im alten Dorfteil liegen an den Gassen Brunnen, aus denen das Wasser in die Häuser getragen wird. Das erste Haus rechts ist das Kulturhaus.

Abb. 18. Das neue Eigenheim-Besiedlungsgebiet im östlichen Dorfteil. Seine Bewohner sind hauptsächlich Pendler. Im Hintergrunde der Wasserturm.

Abb. 19. Neues Eigenheim-Besiedlungsgebiet im südlichen Dorfteil.

Ab. 20. Die Kuh- und Pferdestallgebäude des Genossenschaftsbetriebes sind etwas ausserhalb des eigentlichen Dorfes gelegen.

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A BLACK SPRUCE FEATHER MOSS FOREST IN THE INTERIOR OF SOUTHERN QUEBEC-LABRADOR PENINSULA

BY

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CONTENTS

Introduction

Little has been published on the ecology and structure of the virgin conifer forest of Subarctic Canada. Therefore, some observations from an undisturbed black spruce feather moss forest in the interior of southern Labrador may be of interest.

In the summer of 1952, the temporary observation station on Mecatina Island in Morhiban Lake (51° 50′ N.lat., 62° 53′ W.long., almost exactly halfway between Seven Islands and Goose Bay) was converted into a radio beacon. Thanks to Mr. George Jacobsen, manager of the building firm Tower Co, I had the opportunity to stay with the workers on the island, in an area, which is still a »terra incognita» to geographers and biologists, from June 30th to July 11th 1952. At that date a sudden forest fire swept over the island and forced us to abandon the island.

In this connection, I wish to thank Dr. A. E. Porsild and Professor F. Kenneth Hare, and also the Arctic Institute of North America and National Museum of Canada for their generous funds, which allowed me to do field work in Canada in 1952.

I. General Remarks on the Area

Morhiban Lake is several miles wide and lies more or less at the water divide between the St. Lawrence and the Hamilton River, about 1700 feet above sea level. There are some islands in the lake, among them »Mecatina», about 1 mile long and half a mile wide. The bedrock in the area is granite, with some outcrops on the small skerries and a low hill on Mecatina. The water of the lake is brown, but clear, the sand on the bottom of the shores being dark brown. This is a typical feature of the southern height of land areas also in other parts of Labrador, too; limnologically the lake belongs to the oligotrophic type.

Fig. 1. General view of Lake Morhiban, from NE, in the interior of southern Labrador Peninsula (Province of Quebec).

The southern part of the island is covered with strongly podsolic soil. A noteworthy feature, in addition to the occurrence of ground frost late in the summer (see below) was the absence of charcoal or other signs of earlier forest fires under the vegetation cover of the forest plots studied here. Although the island was on the whole dominated by black spruce (see Fig. 2), small areas where covered with shrubby balsam fir forest, at least partly as a result of a podsolic »hard-pan» in the soil in many places.

The shores of Lake Morhiban are partly low sandy beaches, as on the southern end of Mecatina, partly boulder shores, which have been pushed up by the movement of the ice, very similar to those of Finnish lakes in similar situations. Behind the alder bushes the black spruce feather moss forest grows very near the shore.

The climate of the area is unfavourable (note the height above sea level). It is also variable; Lake Morhiban is situated near the »axis of maximum cyclonal activity» (Hare 1951, p. 658). The lake was frozen on October 21, 1951, and free of ice on June 8, 1952. However, in the beginning of July, 1952, the days were hot with temperatures around 84° F and a prevailing warm wind from the northwest. The snow is deep in this area, the annual mean snowfall being 150—175 inches (Hare l.c., p. 657); similarly in respect of the number of days per annum with a snowfall of 0,1 inches or more, this water divide area is an extreme region.

The »permafrost» pattern was interesting. In the beginning of July, 1952, one could find frozen soil under the feather moss cover. Under sample plot 1 (see below) the soil was frozen 9 inches below the surface on July. On July 3, frozen soil was found 11 inches below the surface, stretching through the thin humified part of the soil and 2 inches under the bleach sand (see p. 10). But after a warm thunder shower and three days of continuous heat wave, which was also responsible for the fierce forest fire on July 11 (which started from partly burned slash), the frozen soil beneath the forest was completely melted, as was verified on July 9. This semipermanent pattern of the ground frost, or what could be called »semipermafrost», is probably a relatively common feature in the southern interior of Labrador. The temporarily frozen soil restricts the growth of trees.

Regarding the general character of the area around Lake Morhiban, see the cover type survey by Hare (1959).

II. The Tree Species.

In this »subarctic» forest on the height of lands there were only five tree species: black spruce, balsam fir, larch, white birch and aspen. Along the shores of the lake, alder (*Alnus crispa)* was dominant. Also a birch bush species (*Betula minor)* was collected. The absence of white spruce is a very characteristic feature of such a forest on granite bedrock in the interior of Labrador.

The dominant tree is black spruce, which forms large muskeg forests and undisturbed feather moss forests in the area. Owing to the hard podsol pan, the semipermanently frozen soil and late melting

Fig. 2. About 200 years old black spruce forest beside a pool on Mecatina Island in Lake Morhiban. Note the about 2 m long branchless parts of the narrow crowns with *Alectoria*-covered remnants of twigs and old cones. In very old trees there are sometimes vegetative shoots above the »cone brush»; note the difference compared with the mature black spruce trees, in the foreground in Fig. 1.

deep snow, the trees are rather small, the biggest black spruces seen during these days being about 42 ft. high and 11 inches d.b.h. (= diameter at breast height) only. The annual growth in height, as in thickness, was remarkably small (see p. 16). Black spruce starts its radial growth around July 1. In borings taken on July 3 and 4, signs of the first new cell-layer of the 1952 wood were seen. The elongation of the black spruce shoots started at about the same time. Regarding the flowering, see Fig. 3. It was noted that black spruce cones may remain on the trees for up to 60 years, which is more than hitherto has been reported (cf. Horton and Lees 1961, p. 19).

Deformed cones with needles growing out of the cones, similar to white spruce cones from the maritime limit (H 1950, p. 12),[1] were noted on an old tree in the feather moss forest.

Balsam fir is regarding habitus in such for the species in general extreme areas very similar to the black spruce. The biggest balsam fir measured was about 48 ft. high and 8 inches d.b.h. Most of the trees formed low, dense thickets (see Fig. 4). The species started its radial growth and shoot elongation a little earlier than the black spruce, for by July 1 the sap of balsam fir borings flowed freely and all the vegetative buds were open. The needles on the balsam fir were here only 1/3—1/2 inch long, i.e. half the ordinary needle length in more southern forest (compare Heikkenen 1957, p. 8).

Larch (tamarack) was not common on the island, although they were fairly numerous on the mainland around the lake on small bogs or in fen-like localities. The biggest larch was about 42 ft. high and 8 inches d.b.h.

All the conifer species showed good vegetative reproduction in the old forest, and even sufficient possibilities for generative reproduction, to judge from the flowering intensity, as noted in the sample plot descriptions.

The white birch (here *Betula papyrifera* v. *cordifolia)* was found only on two small rocky islands north of Mecatina and on a hill on the »mainland» coast to the east. The biggest birch noted was about 30 ft. high and 10 inches d.b.h. One aspen *(Populus tremuloides)* was found together with a few birches on a high granite hill on the mainland coast east of the island.[2]

The Morhiban Lake area (with the probable exception of river and brook valleys not visited by the author) is marked by a poor forest.

III. Sample Plot Descriptions

The descriptions of some sample plots given below follow the same simple pattern as in my earlier papers from northeastern Canada (compare H 1950—54). The structure of the vegetation was estimated,

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[1] The expressions H 1950, H 1954, etc. refer to the authors earlier papers.

[2] In passing, the occurrence of isolated aspens is one of the alluring aspects of the Labrador taiga. This 7.5 m high aspen (about 40 years old above the ground) was probably primarily a vegetative shoot. But how long had it been there?

visually only, according the following simple scale: 3 = dominant (abundant) species, 2 = common species, 1 = scattered species; the sign + indicating occasional individuals of a species. Regarding expressions used for forest types, see H 1949. Phanerogams (see p. 00), except for the common forest plants, were determined by Messrs. H. J. Scoggan, Ottawa, and Marcel Raymond, Montreal, in 1952, cryptogams by Dr Risto Tuomikoski (Mosses), Dr Sten Ahlner and Dr T. Ahti (Lichens).

Sample plot 1, July 1. Black spruce feather moss forest in the centre of the island, 5—6 m above lake level. The trees 21—27 ft. in height and 3—5 inches d.b.h.; their age is 100—180 years; regarding growth, see p. 16. Strongly podsolic soil beneath a feather moss cover about 6 inches deep. Under this a humified layer with seemingly more lichen (decayed remnants) than in the surface vegetation today. Strong vegetative propagation; no generative reproduction noted because of the thick moss layer (see Fig. 6). Ground vegetation: *Pleurozium (= Calliergon) Schreberi* 3, *Chiogenes hispidula* 1, *Cladina alpestris* 1, *C. rangiferina* 1, *C. mitis* +, *Vaccinium vitis-idea* + and *Opisteria arctica* +. Cryptogams collected include: *Dicranum fuscescens, Barbilophozia barbata* and *Lophozia gracilis (= L. attenuata).*

Sample plot 2, July 1. Black spruce feather moss forest on south side of the island, 4—5 m above lake level. 15 bspr on an area 10 x 10 m, incl. one balsam fir. Trees 30—33 ft. high and up to 7 inches d.b.h., generally well grown regarding crown habitus, see Fig. 3. The age of bspr was here approximately 20 years. The bfir on the plot was about 95 years old, 23 ft. high and 4—5 inches d.b.h.

1—2 vegetative shoots of bspr, 10—20 cm high, on one square metre. Ground vegetation: *Pleurozium Schreberi* (9—10 inches deep) 3, *Ptilium (= Hypnum) crista-castrensis* 1, *Chiogenes hispidula* 1, *Cladina mitis* 1, *Vaccinium vitis-idaea* +, *Cladina alpestris* + and *Peltigera polydactyla* +. Cryptogams collected include: *Ptilidium ciliare, Cladina elongata* and the epiphyte lichens *Cetraria ciliaris, Parmelia sulcata, Alectoria jubata* and *Mycoblastus sanguinarius.*

Sample plot 3, July 4. Black spruce feather moss with a few balsam firs on a 25° stony slope on the northeast side of the island. This does not change the outlook of the forest, because stones, trunks and fallen stems are all moss covered. Bspr trees reach about 40 ft. in height and 7 inches d.b.h. Some of the bspr are developed from originally vegetative shoots (which seem more liable to rot), and some trees have grown from seedlings. Frozen soil was noted 11 inches below the moss covered surface. The age of the bspr is here 140—190 years; one bfir is 33 ft. high, 5 inches d.b.h. and 170 years old, another 48 ft. high and 150 years old. Regarding the pattern of flower distribution on a bspr of vegetative origin about 140 year old, on sample plot 3, see Fig. 3 several hundreds of 1951 cones at the top of the tree. On some bspr and bfir trees rot was observed extending to 1 m above the ground. Vegetative

Fig. 3. The upper parts of the crowns of balsam fir and black spruce photographed on July 4th. Note the stage of the new vegetative shoots on the twigs compared with the male and female inflorescenses. The contrast between lower branches with male and upper branches with female inflorescenses is sharp on the black spruce. Usually the growth of the last 10 years of the mature black spruce is almost solely covered by female flowering. On balsam fir the same feature is not as clearly pronounced.

propagation is common on the plot, but no generative reproduction was noted, in spite of intense female flowering (also on bfir). Vegetative shoots can develop into seemingly normal trees with normal inflorescences, but the first growth from the ground to about breast height may take as much as 50 years, and usually 25—30 years. Ground vegetation: *Pleurozium Schreberi* (4—6 inches deep, partly on rotten wood, partly on a decayed *Cladina*-layer) 3, *Ptilium crista-castrensis* 2, *Chiogenes hispidula* 1, *Vaccinium vitis-idaea* +, *Ledum groenlandicum* +, *Hylocomium splendens* (!) +, *Polytrichum commune* +, *Cladina mitis* + and *Peltigera sp.* +. Cryptogams collected include: *Pohlia nutans, Dicranum fuscescens, Ptilidium pulcherrima, Cladonia deformis, C. ochrochlora, C. chlorophaea, C. coniocraea* (see Lepage 1949, p. 356—7) and the following epiphyte lichens: *Alectoria jubata, A. sarmentosa, Cetraria pinastri, Parmelia sulcata, P. cfr. obscurata, Parmeliopsis ambigua* and *Mycoblastus sanguinarius.*

Sample plot 4, July 5. Black spruce feather moss forest about 15 m above lake level on the northeast side of the island. Some of the bspr trees (33—40 ft. high, 2—6.5 inches d.b.h.) are developed from vegetative shoots, some from seed. Age of the trees 120—180 years. The crowns are narrow and growth

is very slow (cf. Fig. 2). Vegetative propagation is common; several trees also show good cone production, however, particularly from 1951. But all trees are slightly rotten and sometimes only the outermost 10—15 rings at b.h. are entirely free from rot (note that on old trees only the outermost annual rings conduct water); still the trees have the normal appearance of a well-grown tree with regular male and female inflorescence distribution (see Fig. 3). No frozen soil was observed. Ground vegetation: *Pleurozium Schreberi* (7—8 inches deep) 3, *Ptilium crista-castrensis 1, Cladina cfr. mitis 1, Chiogenes hispidula* 1, *Opisteria arctica* 1, *Vaccinium vitis-idaea* +, *Polytrichum commune* +, *Peltigera scabrosa* + and *Cladina alpestris* +. Cryptogams collected include: *Dicranum fuscescens, Icmadophila ericetorum* and the epiphyte lichens *Alectoria jubata, A. sarmentosa, A. simplicior, Cetraria ciliaris* and *Parmelia physodes.*

Sample plot 5, July 7. Black spruce feather moss forest with scattered balsam fir on the west shore of Morhiban Lake, 0.5 mile from the shore. The trees here are bigger than on the island, about 42 ft. in height and 8 inches d.b.h. This is a slightly more open forest than sample plots 1—4; the moss cover is continuous but includes some scattered phanerogams such as *Vaccinium angustifolium.* No frozen soil noted. Some of the trees have certainly developed from vegetative shoots, but vegetative propagation is now unimportant. Where the mineral soil is exposed by the fall of a tree, as in this sample plot, several well developed seedlings grow; on one square meter 15 1—2 year old bfir and 6 bspr seedlings were noted. Ground vegetation: *Pleurozium Schreberi* (about 6 inches deep) 3, *Vaccinium angustifolium* 1—2, *Ledum groenlandicum* 1, *Cladina alpestris* 1, *C. mitis* 1, *Vaccinium cfr. cespitosum* +, *V. vitis-idaea* +, *Chiogenes hispidula* + and *Opisteria arctica* +. Cryptogams collected include: *Cladonia coccifera* and *Icmadophila ericetorum.*

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To give an idea of the general vegetation on this height of lands area with the above-described black spruce feather moss forest, the following sample plots of black spruce muskeg and bog forest are included here.

Sample plot 6, July 6. Black spruce muskeg (see H 1949 and H 1950) on the east shore of Morhiban Lake. Bspr reaches 27—36 ft. in height and 5 inches d.b.h. Scattered low balsam fir and nearby a few isolated larches. Vegetative propagation of all tree species noted. No frozen soil. Ground vegetation: *Sphagnum spp.* 3, *Chamaedaphne calyculata* 2, *Rubus chamaemorus* 1, *Ledum groenlandicum* 1, *Smilacina trifolia* +, *Kalmia polifolia* + and *Lycopodium annotinum* +. The cryptogams collected here were lost.

Sample plot 7, July 7. Black spruce muskeg on a big low island west of Mecatina, 3—4 m above lake level. Bspr is here small in size, 21—24 ft. only, with branches reaching to the ground. No frozen soil. Prolific vegetative propagation. Ground vegetation: *Ledum groenlandicum* 2, *Chamaedaphne calyculata* 2, *Sphagnum fuscum* 2, *Pleurozium Schreberi* 1, *Rubus chamaemorus* 1, *Empetrum hermaphroditum* 1, *Equisetum silvaticum* 1, *Kalmia polifolia* +, *K. angustifolia* + *(!), Vaccinium angustifolium* +, *Chiogenes hispidula* +, *Oxycoccus microcarpus* +, *Cladina alpestris* +, *C. mitis* + (on tussocks), *Polytrichum commune* + and *Pohlia nutans* +.

Fig. 4. Balsam fir forest a few months after a fire in the spring of 1952 on Mecatina Island. Note the twisted and deformed outlook as well as the dominant 'layering'. This is a result of the »semipermafrost» and the hard-pan of the podsolic soil.

Sample plot 8, July 9. Black spruce muskeg on the mainland coast about 1 mile southwest of the island, 1 m above lake level, 200 m from the shore. Dominant bspr, 18—21 ft. in height with branches to the ground and scattered tamarack reaching 27 ft. in height and 5 inches in d.b.h. The trees have probably developed from seed; few vegetative shoots, but no generative reproduction noted. Seedlings of larch scattered near the shore. No frozen soil observed. Ground vegetation: *Sphagnum* spp. 3, *Chamaedaphne calyculata* 1—2 (past flowering), *Ledum groenlandicum* (sterile), 1, *Equisetum sylvaticum* 1, *Rubus chamemorus* (flow.) 1, *Smilacina trifolia* (flow.) 1, *Chiogenes hispidula* +, *Empetrum hermaphroditum* (fruct.) 1, *Vaccinium angustifolium* (flow.) *V. cfr. cespitosum* +, *Oxycoccus microcarpus* +, *Kalmia polifolia* (flow.) +, *Carex trisperma* (flow.) +, *Lycopodium annotinum* +, *Pleurozium Schreberi* + and *Cladina rangiferina* +. The trees covered with *Alectoria jubata.*

Sample plot 9, July 9. Black spruce muskeg with scattered larch on the mainland coast, about 1.5 miles west from Mecatina, 200 m from the shore. Dominant trees 27—33 ft. high and 6—8 inches d.b.h.; scattered larch trees reach 30 ft. Growth of bspr rather good and generative reproduction of both

bspr and larch (seedlings 12—16 years old). Ground vegetation: *Sphagnum spp.* 2, *Pleurozium Schreberi* 2, *Cladina cfr. mitis* 1, *Ledum groenlandicum* +, *Chiogenes hispidula* +, *Empetrum hermaphroditum* +, *Equisetum sylvaticum* +, *Rubus chamaemorus* + and *Kalmia polifolia* +.

Sample plot 10, July 9. Black spruce bog forest (see H 1949) 1.5 miles southwest of Mecatina on the mainland coast, 1—2 m above lake-level and about 200 m from shore. Small scattered bspr (9—12 ft. high) and scattered low (2—3 ft.) larches, mostly vegetative shoots. Ground vegetation: *Sphagnum spp.* 3, *Chamaedaphne calyculata* 2, *Eriophorum spissum* 1—2, *Scirpus caespitosus* 1—2, *Carex oligosperma* +, *C. pauciflora* +, *Kalmia polifolia* +, *Vaccinium angustifolium* +, *Cladina rangiferina* +, *C. alpestris* +, *Andromeda glaucophylla* +, *Aster radula* +; nearby *Carex paupercula, Drosera rotundifolia* and *Sarracenia purpuraea.* No permafrost observed in the tussocks.

Sample plot 11, July 1. Fragment of bog forest near small pool in central part of the island. Small old bspr, 3—6 ft., and scattered similar larches (a 2 ft. high larch was at least 50 years old), covered with *Alectoria jubata.* Ground vegetation: *Sphagnum spp.* 3 (the following species determined, see p. 10: *S. magellanicum, S. parvifolium, S. robustum* and *S. apiculatum), Chamaedaphne calyculata* 3, *Kalmia polifolia* 1, *Eriophorum spissum* 1, *Ledum groenlandicum* 1, *Rubus chamaemorus* +, *Smilacina trifolia* +; nearby *Scheuchzeria palustris* and *Sarracenia purpuraea.* No permafrost observed.

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To give a further idea of the poor vegetation on the height of lands and because notes on the flora of the interior of the Labrador Peninsula are very scarce, I here forward a list of vascular plants collected around and near sample plots 1—11. The names of the authors of the species are excluded, since the species mentioned here are all common elements in Labrador with one possible exception, *Littorella americana* Fern. Species mentioned in the descriptions above are not included below:

Dryopteris phegopteris, D. Linnaeana, D. spinulosa, Isoëtes muricata, Lycopodium complanatum, L. annotinum v. pungens, L. selago, Potamogeton spp., Carex deflexa, C. vesicaria, C. gynocrates, C. brunnescens, Streptopus amplexifolius, Luzula parviflora, Calamagrostis cfr. canadensis, Salix planifolia, S. pellita f. psila, S. Bebbiana, Myrica Gale, Geocaulon lividum, Nuphar variegatum, Coptis groenlandica, Amelanchier Bartramiana, Rubus acaulis, R. pubescens, Potentilla palustris, Ribes glandulosum, Littorella americana (det. M. Raymond), *Lobelia Dortmanna, Viola pallens, V. labradorica, Epilobium angustifolium, Vaccinium uliginosum v. alpinum, Pyrola secunda, Linnaea borealis, Trientalis borealis, Viburnum edule, Galium sp., Petasites palmatus, Solidago cfr. multiradiata, Taraxacum cfr. croceum.*

Note the absence from the small area covered by the excursions of *Picea glauca, Mitella nuda, Aralia nudicaule, Maianthemum canadense,* etc.

IV. Tree Growth

The growth of black spruce in feather moss forest is very slow, as can be seen from Tables I and II. 9 black spruces from sample plot 1 above were measured with respect to their growth in height as well as in thickness, thus the Tables II and III and Fig. 5 refer to exactly the same trees. The age and annual ring measurements were taken with an increment borer at d.b.h. from the south side of the trunk. However, the true age of these slowly growing trees (many of them are primarily developed from vegetative shoots, see below), is very difficult to determine (compare Sirén 1950 and H 1950). To reach a height of 3—5 feet a black spruce in this type of forest needs 25—50 years; this was checked on some trees. In passing, it is worth noting that theoretically a vegetatively propagating black spruce tree (as well as other similarly growing conifers, e.g. Juniper), may be many hundreds, and probably a thousand years old, if undisturbed by fungi, insects or fires.

In the black spruce feather moss forests described here, some of the trees have developed from seed, some from vegetative shoots; there seems to be no fixed »rule». Vegetative propagation is prolifiric and the author can fully confirm the pertinent observations regarding the layering and rooting of the black spruce made by Horton and Lees 1961 (cf. also H 1950). However, as vegetative shoots of black spruce can also form a straight stem as soon as the shoot has reached about six inches above the ground, it is not easy to see at a glance which tree has developed from a seed and which from a vegetative shoot. The trees originating from vegetative shoots also flower and form cones like »normal» trees grown from seed. The trees which originally developed from vegetative shoots show a clear bend because of the suddenly released phototropism of the shoots, this is usually a good key to the origin of the tree. Trees which have developed from vegetative shoots seem to rot more easily. Note that the root systems are very superficial and hardly penetrate beneath the humified part of the moss cover, partly because of the »hard-pan», probably also because of the »semipermafrost».

If, as is usual here, the forest is rather dense and the destructive effect of the wind thus small, black spruces which are almost completely rotten inside can still grow seemingly normally with ♀ and ♂

Table I. *Growth in height of depressed vegetative black spruce in feather moss forest.*

Age at ground	Height feet	Diam.at ground inches	Growth in height in mm 1951	1950	1949	1948	1947	1946	1945	1944	1943
about 65 years	9	1.2	15	10	13	9	12	15	12	12	15
70	10	1.4	25	10	20	18	35	50	20	20	21
70	9	1.2	25	10	14	13	20	25	30	20	25

inflorescences and an annual growth in height of 2—4 inches. This is due to the fact that the water-conducting part of a black spruce stem here is very narrow, and sometimes formed by the outermost 10—15 rings only; the thickness at d.b.h. of this healthy outer wood-layer in such cases is 3—4 mm only. The rot may extend up to a height of about 18—21 ft. within such a superficially healthy looking tree. This also explains why the stems which have fallen to the moss floor rot so rapidly once the outermost layers of wood has been broken and »penetrated» by the roots of the plants from the outside.

Table I shows the very slow growth of depressed black spruce vegetative shoots in a feather moss forest. The average annual growth of the terminal shoot is only about 1.5 cm.

Table II illustrates the great difference of the growth in height in different years. Note, for instance, the great increase in height growth from 1946 to 1947 in Table II. Black spruce reacts in this case like pine and other conifers in general to extreme conditions (compare H 1948 and there quoted literature, see also Mortenson 1959 and H 1950, p. 62—63). The growth in height seemingly depends mainly on the temperature during the preceding summer, the growth in thickness on that of the current growing season (see Fig. 5). The growth of the terminal shoot is generally 2—4 inches on mature trees (the expression »mature» is here used to mean trees about 100 years old). The average growth of mature black spruce during the last decade in a feather moss forest appears from Table IV.

Table II. *Growth in height of black spruce.*

	Age at ground[1]	Height feet	D.b.h. inches	Length of terminal shoot in mm														
				1951	1950	1949	1948	1947	1946	1945	1944	1943	1942	1941	1940	1939	1938	1937
1	140	24	4	15	22	60	75	65	25	25	35	50	25	10	35	20	25	35
2	130	30	4	80	60	60	60	100	50	60	35	40	40	40	70	50	25	25
3	140	24	3.6	80	70	100	80	60	30	70	50	20	50	45	40	75	65	50
4	135	21	3.6	60	50	70	70	65	65	40	50	50	20	35	40	50	50	50
5	160	30	6	80	80	120	110	100	45	40	50	70	70	70	80	60	80	90
6	110	18	3.3	90	80	90	60	70	50	40	35	30	30	60	60	50	55	35
7	160	21	3	40	70	35	30	50	25	40	50	40	35	40	60	20	30	20
8	135	21	3	100	70	110	80	75	35	60	20	30	30	60	100	100	90	110
9	120	27	3.6	80	40	60	50	70	40	50	35	60	30	70	50	50	60	40

[1] Estimation only, based on tree-ring counts at d.b.h. with about 30 years added, see p. 15.

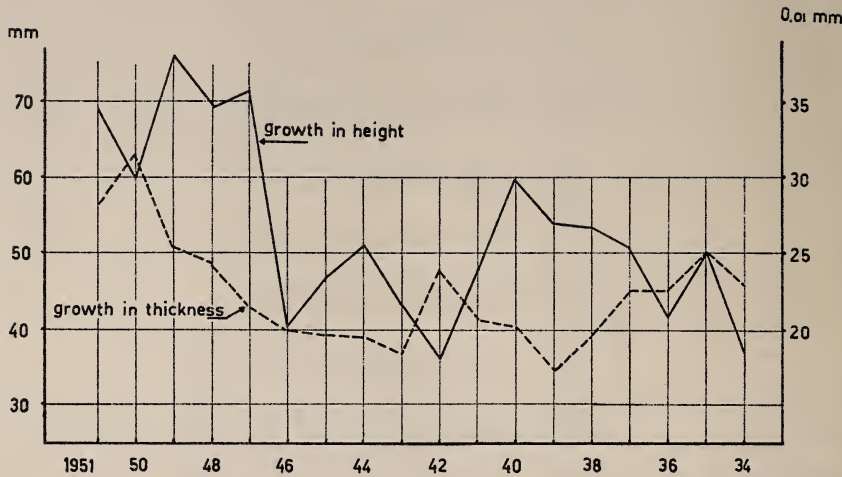

Fig. 5. Comparison of growth in height (in mm) and growth in thickness (radial growth in 0.01 mm) measured on nine black spruce trees from sample plots 1—5. Note that the maxima in growth in height and thickness do not coincide; an interesting exception occurred seemingly in 1935.

Table III. *Growth in thickness of black spruce, 1937—51.*

	Width of annual rings, in 0.01 mm[1]														
Tree Nr[2]	1951	1950	1949	1948	1947	1946	1945	1944	1943	1942	1941	1940	1939	1938	1937
1	31	26	17	21	17	11	17	15	12	13	12	11	8	10	12
2	15	15	16	13	14	10	15	10	23	17	13	13	8	20	17
3	40	45	29	27	23	34	28	32	21	34	35	29	26	22	35
4	27	26	25	19	18	21	20	18	19	27	22	19	17	21	21
5	32	44	42	39	36	28	24	26	23	38	29	30	24	23	33
6	37	48	36	29	26	19	22	24	20	21	20	24	17	21	24
7	14	11	9	11	9	11	8	11	7	10	11	11	9	10	11
8	34	38	26	32	28	27	28	28	29	34	27	24	26	25	27
9	24	31	29	29	23	18	15	14	13	25	18	21	22	19	24

[1] The measurements were made with microscope.
[2] See Table II.

Growth in thickness, measured in 0.01 mm, from borings at breast height is given in Table III. In Table III the annual differences are likewise great. This is always the case in climatically severe or ecologically extreme conditions (note, for instance, the general observations on tree growth in H 1956). Here the summer is short and the growth period hardly more than one month. In a forest situated like the one described here, the »climatic hazard coefficient» (i.e. the variation coefficient, $^0/_0$ σ/M; $\sigma =$ the standard deviation) of the growth series of a longer period, such as a tree ring series, must be rather high (H 1948, p. 50).

Table IV. *Growth of black spruce 1942—51 in feather moss forest.*

	Height	D.b.h.	Average annual growth in height	Average annual growth in thickness
Average age	feet	inches	mm	mm
Group *a*: 136	24	4	51	0.46
b: 150	30	5	56	0.38
Extreme growth				
group *a*: 160	21	3	41	0.2
b: 180	39	6.5	43	0.17

Note. Group *a* are trees in Table II, group *b* are 7 trees from sample plots 3 and 4.

A tree-ring series 1818—1946 from Mecatina Island, based on 13 black spruces, is included in H 1956. However, because of the position of these forests in a climatic »disturbance» area (see Hare 1951) and the not only climatically but also ecologically extreme conditions, I do not consider the series above very informative regarding the annual variations in the climate. But the series show clearly the extremely slow growth in general in a such forest in such an area.

In this type of forest, the growth in thickness, as Table IV illustrates, is very slow. Wilton (1959) gives much needed information regarding the yield of black spruce in undisturbed feather moss forest in the Lake Melville area. According to Wilton (l.c., p. 12—14), the average merchantable volume for four areas sampled was 25.3 cords per acre. However, the trees in the Lake Melville area show a better average height and d.b.h. than the trees described here. The

Fig. 6. Close up of the black spruce feather moss forest type (in the center with scattered balsam firs). The biggest trees on the pictures are about 10 inches d.b.h. The dominant feather moss species is here *Pleurozium Schreberi.*

climate in the Lake Melville area is more suitable for tree growth than in the elevated water-divide area described here. Wilton's stand and tables for this type show an average of 1360 trees per acre, more than half of them being of merchantable sizes. The forest described here probably has not more than 1000 trees per acre; the average size of the trees is around 27—30 ft. in height and 4 inches d.b.h.; the yield is probably not more than 10 cords per acre. The annual growth on sample plot 1 is probably only 0.1—0.15 m^3 per hectare.

Lafond (1956) estimates the yield from his *Calliergon* forests (= *Pleurozium Schreberi* dominated black spruce forest) on Quebec North Shore Paper Company concessions to 18—35 cords per acre.

The slow growth of black spruce in such feather moss forest depends on several factors, mainly, of course, the short growing season (see below). Regarding black spruce in general, see i.a. Le Barron 1948.

V. The Black Spruce Feather Moss Forest

»If there are any such things as climax forests in nature, the spruce feather moss forest is certainly one of them» (H 1949, p. 39).

The undisturbed black spruce feather moss forest is in many ways a beautiful and an interesting forest. The growth of the trees and of the occasional phanerogams (see above) is slow in the extreme, as the above mentioned facts illustrate. The moss cover grows indefinitely covering stones or fallen trunks, filling out small depressions

and it decays extremely slowly on the podsolic ground. Animals seem to avoid this type of forest. Black epiphytic lichens are well developed and cover the twigs even before they are dead. The peace of death hangs over this forest.

The age of the trees does not much exceed 200 years, see Table II. The reason is the keen root competition in the badly aerated ground, where hard-pan formation makes the root systems shallow. Likewise the heavy snowfall, which melts late, is a factor to consider. Rot is rather common, particularly in trunks which originally developed from vegetative shoots (see above). But flowering and fruiting seem to continue into an old age.

The moss cover in this more or less acid ground is composed of *Pleurozium (= Calliergon) Schreberi,* a common circumpolar feather moss species. In covering old trunks and decaying stems, *Ptilium (= Hypnum) crista-castrensis* seems to play a more prominent rôle than the other feather moss species. *Hylocomium splendens (= H. proliferum)* does not seem to be as common here as in many other areas (compare sample plot descriptions). The annual growth of *Pleurozium* and *Ptilium* is not easy to judge; in this respect *Hylocomium* is an »easier» species (compare Tamm 1953).

The author tried to make a microscopic study of *Pleurozium* and *Ptilium* samples from plots 1—4, but the result was not satisfactory; the annual growth in height could not be defined properly. However, values of about 0.2—0.4 inches seem to be good estimates for the annual growth. The living part of the *Pleurozium* and *Ptilium* is here only 1—2 inches long.

The epiphyte lichens and small lichens on the old and dead twigs are cosmopolitan species, their value as phytogeographical indicators (compare, however, Ahlner 1948) is small, but they are, nevertheless, very typical of these old feather moss forests. Sometimes *Alectoria spp.* cover a third or a half of a tree crown. In the moss cover *Cladina spp.* appear in places as remnants of an earlier richer lichen flora. The cryptogam flora is comparatively rich in species (compare the few notes from the sample plots). Unfortunately, the fungi were not studied.[1]

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[1] One sample taken on the lower part of a black spruce (vegetative shoot) was determined by Prof. V. Kujala as the European species *Trichoscyphella calyciformis* Willd. According to him, this European species is identical with *Lachnella Agassizii* (Berk. & Curt.) Seaver.

Fig. 7. *Chiogenes hispidula* takes an active part together with *Pleurozium Schreberi, Ptilium crista-castrensis,* etc. in covering the decaying trunks.

The feather moss cover is dense and does not permit black spruce or balsam fir seeds to grow unless a sudden windfall creates suitable »seed beds» of mineral soil. But decaying trunks also make excellent seed beds (compare i.a. Place 1950). On the mineral soil left open by the shallow root system of the fallen tree one finds well developed young black spruce seedlings in an otherwise dominant feather moss cover. On such open soil phanerogams easily intrude in the closed forest and change the pattern of the ground vegetation — transiently. For a time the phanerogams flower and fruit, until there are only sterile shoots left. Thus, even in the closed feather moss cover one finds individuals, usually poorly developed, of *Ledum groenlandicum, Vaccinium Vitis-idaea* and *Chiogenes hispidula* (»creeping snowberry»). Of these, the snowberry grows best in this habitat; it is usually also the first phanerogam species to cover decaying trunks on the shady side (see Fig. 7), sometimes with bilberry penetrating the wood on the other side. The covering capacity of *Pleurozium* and *Ptilium* is also notable (see Fig. 6). *Empetrum hermaphroditum* is not commonly seen in such forests.

The trees in a feather moss forest usually grow in clumps. The reason for this is partly the above mentioned fact that the seeds can develop only on suddenly exposed mineral soil or on a decaying wood stem not yet buried by the moss. In other cases the »uneven distribution» of the stems is a result of the general vegetative shoot forming habit of the black spruce and balsam fir. The »candelabrum» tree form (H 1949, H 1950) is not so well developed here as on the open lichen woodlands, where the shoots can develop freely in every

direction. However, a certain »candelabrum» pattern can be discerned in the black spruce feather moss forest when a careful search is made.

In this area, where no sign of charcoal could be seen in the ground, one would have expected a thick humus layer. But on the contrary as could be seen on the sample plots, the decayed humus layer is very thin here and its unhumified parts in some cases show relatively more lichen remnants than grow in the surface cover. One could also see *Cladina* species slowly degenerating among the feather moss, as sample plot 3 shows. The notes give the impression than the feather moss forest on the southern part of Mecatina island has almost regularly invaded an open lichen forest, a succession which I fancy is not uncommon in Labrador (compare notes from Knob Lake, H 1954). If the forest is undisturbed by fire, such a development must take several hundreds of years and still the humus layer is extremely thin.

It must be noted that the root systems of the trees do not penetrate deep; the trees therefore compete in a poorly aerated and nutrient-deficient substrate with intruding phanerogams. When these slowly die out, the reason is not only the more active growth of the moss cover, but certainly also the root competition from the trees.

Here, the humified layer formed by the interwoven and decaying parts of moss and roots, etc. do not form as hard and thick a cover as the socalled »kuntta» in northern Finland in the somewhat similar *Hylocomium-Myrtillus* forests, see below.

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In H 1949 an attempt was made to compare the conifer feather moss forests on the Quebec-Labrador Peninsula with similar forests in other regions; the *Hylocomium*-forests of Heimburger (1934) from Adirondacks and the *Pleurozium-Kalmia-Vaccinium* forests described by Kujala (1945) from the North Shore (of St. Lawrence) show similar features. Cf. also Linteau (1955, p. 17) who noted *Hypnum*-forests which »may be considered as the climax» among forests. Lafond's »*Calliergon*-type» (1956, p. 11) has as dominant feather moss species *Pleurozium Schreberi,* as the feather moss forests described above. Cf. H 1950 regarding black spruce feather moss forest in the area east of Hudson Bay. In H 1954 the author points out that »a young feather moss forest is seldom found: the trees are generally 100 years

old, often 150 years»; the number of phanerogam species is small, usually remnants of an earlier richer flora of vascular plants and the »feather moss forests do not seem to be so well developed here (e.g. Knob Lake area) as in the granite-gneiss lowlands» (l.c., p. 29).

In northern Ontario black spruce feather moss forests occur in similar bedrock and drainage conditions, compare the author's fragmentary notes from upper Severn River area at Big Trout Lake (H 1957). From Manitoba Ritchie (1956, p. 528—30) describes »closed black spruce forests» which partly can be called feather moss forests; he also made pertinent observations regarding the soil conditions and noted in July e.g. frozen soil 1.5 m beneath the surface. Moss' »*Picea mariana-Hylocomium splendens* association» from Alberta is strikingly similar to the authors black spruce feather moss forest: »The older and denser parts of the stand have an almost continuous feather moss carpet, accompanied by much *Vaccinium vitis-idaea minus,* patches of *Peltigera* and a liverwort *(Ptilidium* sp.) and occasional clumps of *Ledum* and *Empetrum*» (1953, p. 220).

In many respects the well studied *Hylocomium-Myrtillus* forests of northern Scandinavia and Finland can be compared with the Canadian forests mentioned above. However, it seems that there are not so extensive pure and poor feather moss forests in northern Europe as in the Canadian taiga. The amount of vascular plants (usually *Vaccinium Myrtillus)* is always more predominant e.g. in the Finnish forests; regarding their structure and development compare the important work by Sirén (1955) and the general description by Kalela 1961, a.o. I mentioned above that the »kuntta» (e.g. the hard stratus of the decaying moss) does not seem to be so well developed in the feather moss forests I have studied in Quebec and Ontario, as in northern Finland. The reason for this difference, here only mentioned in passing as an observation so far insufficiently verified, is probably the difference in the length of the summer days; the growth season can be as cold and the snowfall and podsolisation as strong in parts of central Lapland as in Labrador. The almost continuous light in the short growth season in Lapland must be taken into account when comparing the ecological pattern of two superficially similar forest types.

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[1] This paper was nearly printed before Wilton's paper of 1964 was published. Wilton describes the forest types of the Newfoundland-Labrador and gives i.a. a good sum-up of the characteristic features of the spruce feather moss forest, »this most heterogeneous forest type of Labrador» (1964, p. 27—28).

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SOME COMMENTS ON THE STRUCTURAL GEOLOGY OF GOMERA
(Canary Islands)

BY

HANS HAUSEN

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Abstract

The following is a short description of the main structural elements of Gomera and the development of the formations, which are all of a volcanic nature with the exception of some small intrustive bosses in the basement complex. (peridotites to gabbros). The volcanic activity which took place in at least three periods in the Tertiary has long since terminated, and the island's surface bears the stamp of old age; it is dissected by a radiating system of valleys. The relatively high position of the basement complex is remarkable in view of conditions prevailing in the other islands of the archipelago.

Introduction

The small island of La Gomera (378 sq. km., c. 150 sq. ml.) one of the so called Islas Menores reveals interesting geological conditions differing generally from those on the other islands. The author studied the island first in 1950 and then in 1963, in the latter year for several months. Material collected in the field has still not been thoroughly investigated, but some very salient facts of geological nature can be presented here in rather general terms.

Gomera was scarcely known geologically until fairly recently. The first investigator to make a comprehensive report was Lucas Fernández Navarro (1918). Likewise Curt Gagel (1910 and 1925) made many interesting observations on general geological conditions which attracted the author's attention.[1] Later, Wilhelm Müller (1930) carried out several

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[1] In 1958 Maurice Blumenthal made a reconnaisance trip to the Canaries and visited Gomera. Judging from his short descriptions (1961) his general impressions are in conformity with Gagel's.

chemical analyses of rocks from La Gomera collected by Gagel and made some comments to which we shall return later. More recently the Canary Islands geologist Telesforo Bravo has devoted a considerable time to studying the geology of Gomera, but the results are still unpublished. I cannot therefore refer to Bravo's findings, which appear to include both structural and petrographic observations.

Physiography of the Island

Despite its rather short circumference Gomera appears as a high island, with the central point of culmination rising to 1 375 meters (c. 4 200 feet) in the Alto de Garajonay. The coasts are steep, especially in the north and west. The centre is occupied by an undulating upland from which *barrancos* radiate in all directions. Some of these are broad, like Valle Hermigua and Valle Hermoso at the northern coast. The island has the stamp of old age compared with others in the Canary group (apart from Fuerteventura), and the relief has been outlined by erosion and weathering. Volcanic constructive forms are practically absent, although the entire structural material is of a volcanic nature. These facts indicate that volcanic activity ceased a long time ago. The orifices of eruptions could hardly be more localised, with the exception of some small adventive cones.

The bedrock has been altered throughout by weathering, and thick soil covers much of the surface. Owing to the moisture of the clouds brought by the trade wind which sweeps over the island and the »barlovento» slopes, these hillsides are covered by a relatively rich vegetation (*laurisilva,* etc.). On the other hand, the southern, »sotavento» slopes are barren (steppe).

Main structural features of the island

The first geological research here was undertaken by L. Fernández Navarro, and from this much detailed and important information including chemical rock analyses has been derived. But Navarro seems to have been completely misled regarding the geological structure. He did not observe the basement complex on which all the later formations lie,

which here form a *cobertera*. It was C. Gagel (1925) who realised that there is a remarkable interior structure, revealed by the presence of many deep valleys showing huge geological profiles *(»man kann alles photographieren»)*. Gagel recognised a decomposed basement complex rising to great heights on the north coast, a complicated structure of lavas, intrusive bosses and dikes. Upon this basement extends a series of flatlying basalts and salic lavas (trachytes and phonolites). These upper strata of lavas and tuffs are generally inclined slightly towards the south coast along which no basement rocks appear.

The hiatus between the basement complex and the *cobertera* seems to be a very large one according to Gagel.

Travelling in all directions across the islands, the author was able to realize how correct was Gagel in his conceptions. Gomera is indeed a very fine example of an island belonging to an archipelago, whose basement can be so well-displayed that its geological history may be read like an open book.

The basement complex and its roques

To study the basement in detail one has to turn to the north coast, to the lowest parts of Valle Hermigua and Valle Hermoso and follow their slopes backwards (uphill to the limits of the cobertera). Many interesting details are revealed here. This is not the place to characterize the rock types and mutual relations, but it may be pointed out that the fundamental complex consists of »spilites», a collective name for basic lavas in great succession that have been turned on edge, probably the same as those appearing in the old basement of the neighbouring island of La Palma. This spilite series is penetrated by innumerable dikes of a varying nature and by bosses of granular rocks of a mainly basic composition (peridotites, pyroxenites, gabbros). There are also many irregularly distributed trachytic intrusives forming dykes as well as major intrusive bodies.

A most remarkable fact already pointed out by C. Gagel is the intense weathering of the basement, especially the intrusives just mentioned. For example, the trachyte intrusions have been almost completely altered

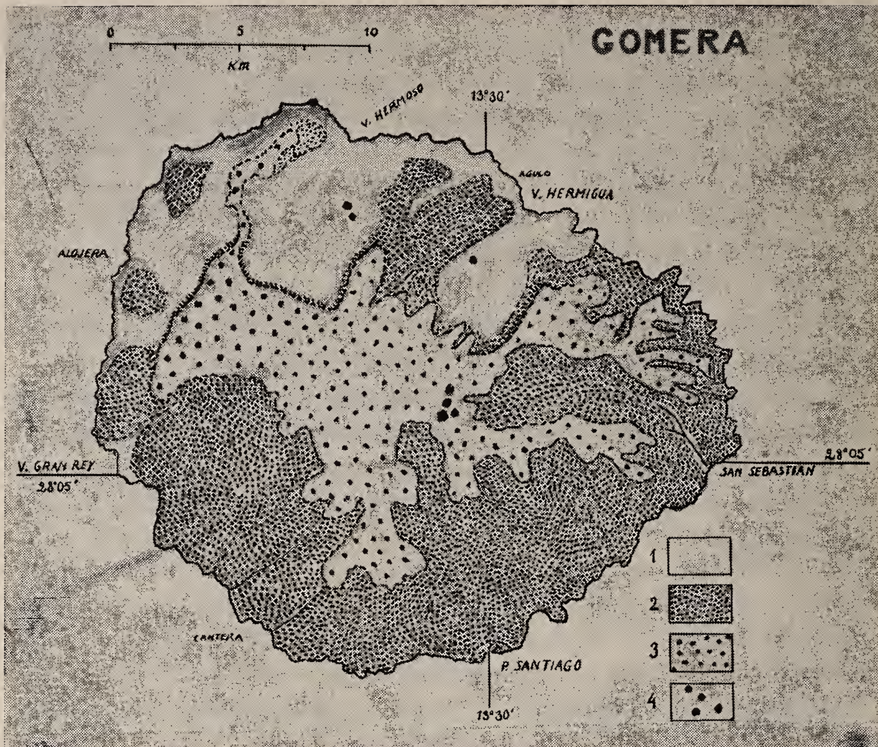

Figure 1. A geologic sketch map of Gomera drawn by using a base map, scale 1 : 50 000 • 1 — the old basement (spilites) and intrusive bodies • 2 — the alk.basalt formation of the **cobertera** (lavas, tuffs and slags) • 3 — phonolite-trachyte formation of the **cobertera** — with tuffs • 4 — roques of phonolites and trachytes — volcanic chimneys isolated by erosion.

into a kaolin mass, of which a sample can be cut with a knife. The basic granular rocks have disintegrated into a coarse sand of greyish-black colour.

The intensity of these chemical and mechanical changes varies surprisingly often, also in a vertical zonal way, reaching deep levels. It is obviously not connected with the surface-hence, it may be a phenomenon of a non-atmospheric nature, which makes one think of hydrothermal action with circulating bicarbonate or sulphurous solutions.

The slopes above the village of Alojéra are one of the most interesting places to study the phenomenon. This is on the western coast (see map).

Here, huge cliffs of a basic, granular, pyroxene-rich rock have disintegrated due to mechanical decomposition, and masses of black sand have accumulated on the shore below. Portions of this sand have drifted south along the shore to form the Playa del Inglés, a black beach a few miles north of the Valle Gran Rey delta.

The abundance of altered trachyte bosses and dikes is astonishing; they are well displayed in the steep slopes surrounding the upper Valle Hermoso.

Los Roques

A typical feature of the physiognomy of Gomera are the stacks of rock masses rising here and there above the general erosion surface. These consist- as shown by L. Fernández Navarro (1918) of trachytes and phonolites. He was inclined to consider them as being something like the top of Mount Pelée in Martinique, but that cannot be the correct interpretation. They are most likely to be the throat fillings of old volcanoes isolated by erosion, which is also a rater common phenomenon in Grand Canary. These lofty »fingers» in the landscape of Gomera bear impressive witnesses to the amount of denudation since the end of salic volcanic eruptions.

The most remarkable assemblage of such rocks is to be found in the divide between the drainage of Barranco de la Villa and that of the Barranco de Santiago, in the central part of the island. It seems that it was an important centre for the eruption of salic magmas which spread over surrounding areas lava sheets and tuffs.

The geological age of the *roques* seems to be considerably younger than that of the basement »spilites» and the dikes; some of which salic in composition, may however, belong to later periods.

The covering volcanic formations

Gomera has an extensive roof of flat-lying sheets of lavas, tuffs and agglomerates. As can be seen from the map, they cover most of the island's surface- southwards down to the seashore, and also in the east.

In the north and partly in the west the *cobertera* has been stripped off, revealing the basement complex, as mentioned above.

This »roofing» is most conspicuous when seen in the great profiles of the north, e.g. in Valle Hermigua. The high-lying sheets show a distinct limit towards the underlying basement (»*Gelände- knick*»- Gagel). That limit is also manifested in the topographical map as caused by tightlyrunning isohypses, indicating *escarpaduras* that surround the large valleys. These *escarpaduras* are the result, not of tectonic fractures, but of erosion.

The lithologic composition of the *cobertera* is twofold. There are extensive sheets of trachytes and phonolites, lavas, tuffs and agglomerates, but there are also important series of basalt lavas and their pyroclastics. These two kinds of volcanics lie one upon the other only in parts, so that the salic series is the younger one (as already observed by Gagel). In other sectors there are either salic volcanics or basalts.

A glance at the geological map shows that the basalts dominate in the south as a broad zone following the coast line. Large exposures are also observed in the south-west. On the other hand, the salic volcanics occupy the central uplands as an extensive shield which sends numerous »arms» in different directions- the result of differential erosion of the *barrancos.* Some of these »arms» actually reach the coast, as in the extreme east.

It seems obvious that the distribution of the different volcanic series must depend on displacements at some time or at different periods. The influence of erosion followed these.

A. The basaltic series of lavas, tuffs and agglomerates

It is not clear where the orifices (or a set of several of them) can be placed. Perhaps the centres of eruption were situated beyond the present circumference of the island. The emission of the lavas was very abundant, and the same is true of the tuffs. This can be proved by examining the gigantic *barranco* profiles in Valle Gran Rey, which forms some of the highest cliffs in the island. The succession of the volcanic beds indicates that rather a long span of time was required in their construction. If the volcanics were accumnlated on the sea floor- as was the case in some of the other Canary Islands with their »table land

series»- the island must have been uplifted more than 1000 metres since that time. Such a rise of the basement was obviously connected with displacements along fault lines, a phase in the development which vill be referred to later.

We can state quite certainly that the entire island in its present shape was covered by basaltic flows and ash sediments. This cover most probably extended far to the north, to beyond the present coast, and also to the west. There was a continuation in an easterly direction towards Tenerife, and it is likely that a connection existed here between the two islands. L. Fernández Navarro (1918) suggested this land connection. The basaltic series of Gomera may be of about the same geological age as the old basalt formation in Tenerife, forming- apart from Teno -Pedro Gil and the Anaga peninsula.

It is obvious that before the expansion of the basalt lava sheets and the deposition of their tuffs there elapsed a long interval during which great disturbances in the »spilite» series took place, as well as many intrusions of magmas of different composition and- later on- base-levelling. The plane of separation between the old fundament and the basalts is a *plane of unconformity reminding* one of that revealed in the interior of the Caldera de Taburiente in La Palma.

The maximum thickness of the basalt formations of the *cobertera* is many hundred metres, as may be seen in the great cliffs in the lowest part of the Valle Gran Rey in the west. According to the topographical map, one can find here a thickness up to about 700 metres, if not more.

In his paper, L Fernández Navarro (l.c.) has given many interesting details about the petrography of these basalt lavas.

B. The formation of the salic volcanics

We must now consider the extensive sheets of trachytic and phonolitic lavas and tuffs forming the upper part of the cobertera. They were laid down during a rather long period following that of basaltic vulcanism. The original expansion was far wider-reaching than is now the case. Much of it has been destroyed by displacements and erosion, as may be seen from the geological map. As has already been mentioned, the salic series covers the basalts, but not everywhere. In some parts

of the island the salic volcanics lie immediately on the basement rocks where there are no signs of the basalt series. Obviously, there must be a hiatus between the two formations of the *cobertera,* comprising displacements and erosion.

The sheets of the salic volcanics are most easily seen in places where they form *escarpaduras* on the valley sides, with potent lava sheets showing columnar jointings. There seems to be always a thick layer of reddish calcined tuffs at the bottom of the formation.

Erosion has been intensely active in the *cobertera* since the time of its expansion, as we have already seen. But an undulating upland has been left in the centre of the island, with Alto de Garajonay forming its culminating point. The border of the highland is a very sinuous one, and there are several outliers or *fortalezas,* patches of lava sheets which were left isolated. The best known of these is that of Chipude (1243 metres), considered by Fernández Navarro as a chimney like the other *roques* on the island. But it does not give the present author (who visited the hill) such an impression. It seems to be a typical outlier, part of a potent lava sheet isolated on all sides by erosion. Montaña de Calvario, to the south of Alojeró is another similar *fortaleza.* A very extensive meseta of the same kind lies in the west above Alajéra, extending between the upper Valle Hermoso and Arure (north of Valle Gran Rey). It shows a great escarpment to the west, at whose foot can be seen how the basal tuffs of the phonolites lie *immediately* on the (weathered) basement rocks.

A glance at the geological map suggests that the centre of the salic eruptions was in the middle of the upland (in the Alto de Garajonay region). Here, however, no signs of a former orifice can be seen, so that one is inclined to suppose instead that the centre lay somewhat to the east, where the assemblage of roques mentioned earlier is situated. These *roques* are now completely separated from the surroundings by deep erosion. This effect seems to be derived from the intense weathering of the fundament that forms the ground around the roques.

There were other centres of salic lava emission, however, such as the prominent Roque del Cano above the town of Valle Hermoso. Much lava was certainly emitted from that chimney (neck) and from several similar ones in the vicinity. Now, thanks to vigorous erosion, these lavas have all disappeared, and only the chimney fills of phonolite remain standing in bold relief (see the photo fig. 2).

Figure 2. A roque of phonolite above a crest of weathered basement rocks to the southeast of Roque del Cano, east side of Valle Hermoso • Looking west • Culminating point 547 m • C = contact line. H.H-n photo • 1963

It seems most likely that a great deal of the dikes and smaller intrusive bosses in the basement complex, which have in many cases undergone intense alteration (kaolinized, etc.), belong to the volcanic phase of the trachytes-phonolites. The hydrothermal actions may be related to these intrusions (post-magmatic phase). Strangely enogh, some *roques* seem to have escaped these alterations.

Wilhelm Müller (1930) published a report on the results of chemical analyses of Gagel's material. The analyses refer to the »basement rocks» (»*das Grundgebirge*»), and comprise partly basalts and partly trachytes and phonolites. The results will be discussed elsewhere. It may be sufficient to state here that Müller's conclusions are strictly opposed to

Gagel's idea. He does not recognize any difference in the state of weathering between the basement complex and the *cobertera.* According to him, no hiatus between the formations, so strongly emphasized by Gagel, exists. The writer considers that there must be some misunderstanding in this difference of opinions, perhaps because of confusion about the localities where the samples were taken. Of the kaolinized trachytes, Müller observed some extreme types with Al_2O_3 surpassing 21 weight %.

As we have seen, the geological appearance of the salic lavas is rather many-sided. Apart from the wide lava sheets of the *cobertera,* we have the chimney plugs, (the *roques*) and the innumerable dikes that cross the basement complex, as well as some intrusive bodies of varying shape. There are some good exposures of the latter in the cliffs of the south coast, forming pale-coloured laccolitic masses in contrast with the dull-coloured host rocks (the basalts). Such a locality is La Cantera, half way between Playa de Santiago and Valle Gran Rey. In other cases there are sills of phonolites of impressive thickness intercalated in the basalt series.

There are also abundant tuffs in the salic series. These are often red, but also of paler colours, like the thick banks exposed in the crest forming the right side of Barranco de la Villa (a tectonic valley). The eruptions of salic material may have been of a highly explosive nature in places, since in the north-eastern sector of the island there are signs of ignimbrites, which cover the basalts. There are, however, still not sufficient data about such types of rocks.

In short, the magmatic evolution of Gomera seems to have followed lines similar to those found in the other islands of the archipelago. Here we have changes between basic and salic magmas, whereas internediary magmas seem sparse. It is an example of 'contrasted differentiation' belonging to a cycle of rather a remote period of vulcanism.[1]

On the other hand Quaternary and Recent eruptions of lavas of basaltic nature seem to have been practically missing, this in contrast to

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[1] Referring to the 13 analyses of Gomera rocks published in his paper in 1918, L. Fernández Navarro stresses the fact that both the salic and basic group of volcanics are sodium-rich rocks. In the basic series the alkalinity does not appear so much in the feldspars as in the aegirinic augite, whereas in the salic series the alkalies are contained in the feldspars and in aegirine (which is very abundant in these rocks). Gomera stands- at least with regard to the cobertera- as a typical representative of an Atlantic magmatic subprovince.

the conditions in the other Canaries, where this basaltic phase is of great importance.

If we wish make a time comparison with the neighbouring island of Tenerife, Gomera seems to belong to the ancient period during which the basalt formations of Anaga, Pedro Gil and Teno were built, and which comprises the subsequent emissions of salic volcanics in the shape of *roques,* sheets and innumerable dikes. The basement complex, which is so well exposed in Gomera, does not appear in Tenerife. Here it can only be suggested, and the same is the case with Hierro.

Displacements by fault movements and subsequent erosion

Gomera is a typical horst island, bounded by fault lines on all sides. It is shaped as a southward-tilted block, with its northern border rising to an approximate maximum of 900 metres. There are also high cliffs in the west. Erosion was invigorated by this faulting activity and the rise of the island block. This is especially true on the north side, where there are the deep erosion embayments: Valle Hermigua and Valle Hermoso. In all other directions barrancos have been incised into the island block, some of them being controlled by fault lines. This is true of Barranco de la Villa and Valle Gran Rey, not to mention several other barrancos. No other island in the Canaries has been affected by erosion as much as Gomera, and — as has been mentioned — this island bears the marks of old age.

Consequently there are two factors determining the physiognomy of Gomera: faulting and erosion (in combination with weathering).

Hence the island was much larger formerly than now, and there was a continuation in the north and in the west. In the north, at Agulo, one can find an *escalón,* a staircase displacement on which a *pueblo* has been built. This platform is backed by a high and nearly vertical cliff cut tectonically into the basalt series which is here exposed. There are mountain blocks of a similar nature on the west coast, which have moved seawards from their former high positions and been arrested half way down the slopes.

There is some uncertainty about the date of these displacements in the island block. First, there was a tectonic phase before the expansion

of the salic volcanoes in the *cobetera.* This can be observed in the Arure region in the west. To the north of the village the phonolite formation lies immediately on the old basement, whereas to the south of it the potent basalt series suddenly appears to a thickness of 700 metres. In the village itself it is crowned by a phonolite sheet.

However, most of the fault movements are relatively young. They have affected the whole *cobertera* and tilted it to the south, cutting off the seaward continuations.

With regard to erosion in Gomera, of course intimately related to the block movements, we must, however, notice that a long process of denudation had nearly peneplaned the area in times antedating the main tectonic movements. This occurred after the cessation of the salic volcanic eruptions from the earlier mentioned chimneys. An erosion surface was formed. Its certain smoothness includes rolling forms and broad valleys and basins. But this smoothness is interrupted by the roques standing in grotesque disharmony with the surroundings. In that way the first phase of erosion took place, if we disregard a phase corresponding to the time between the basaltic and salic effusions of the *cobortera.*

Then there followed a completely new cycle connected with the uplift of the island block; the entire pattern of the *barrancos* and deep valleys was formed. This new erosion cycle is on its way to conquering the whole island, but some of the central upland with its ramifications is still remaining. In this way Gomera displays two distinct physiographic regions- one, an old surface in the highland, and another, a young one in the coastal regions. The latter show a wild erosion landscape recalling Anaga in Tenerife. The erosion of many *barrancos* has been facilitated by lines of weakness coinciding with faults, as is the case with Barranco de la Villa in the south-east, for instance.

Along the east coast are there some samll cones which have been half-destroyed by erosion and are probably connected with the fault lines which separated Gomera from the neighbouring parts of Tenerife.

More detailed studies are needed, however, before we may obtain a full picture of the tectonic and morphologic development of the island.

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ACTA GEOGRAPHICA
18

Text 171 pages; 48 figures in the text, one appendix-map and 6 plates.

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